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THE

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No. I.—JANUARY, 1879.

ORIGINAL ARTICLES.

I.—On the Tripartite Classification of the Lower Palæozoic Rocks.

By Charles Lapworth, F.G.S.

BY those accustomed to the hopeless confusion of the *Greywacké* of the earlier geologists, the publication of Murchison's grand work on the "Silurian System" was hailed with feelings of the most profound relief and satisfaction. His clear and brilliant presentation of the physical and palæontological proofs of an orderly sequence among the Palæozoic Rocks below the Old Red Sandstone, as originally set forth in all their force and harmony in his magnificent volumes, naturally astonished and dazzled the majority of his scientific contemporaries, and secured for his nomenclature of these ancient deposits an almost universal acceptance. His subsequent abuse of this advantage to strengthen and consolidate his own system at the expense of that of his equally-illustrious co-worker—the less fortunate but more cautious Sedgwick—was a gallant but unscrupulous defence of this original nomenclature, which by that time he must have felt himself almost powerless to disturb. His later extension downward of the limits of his System, till it embraced all the rocks between the supposed Azoics and the Old Red Sandstone—though, in a measure, forced upon him from without—ought perhaps to be regarded in part as a very natural return to the ideas of his early teachers, who had always held the practical unity of the rocks of the *Transitional* period. In this way, however, Murchison unwittingly destroyed many of the most beneficial results of his own labours; in a sense, spending his old age in the attempted re-erection of the very edifice it had been the pride of his manhood to destroy—the early years of his scientific career being devoted to the worthy task of proving the marvellous variety of the Lower Palæozoics; his later years to demonstrating their integrity, unity, and indivisibility.

At the present day it would be wholly superfluous to enter upon the discussion of the vexed question of the respective claims of Sedgwick and Murchison to the *Middle* and *Lowest* Divisions of the Lower Palæozoic Rocks. We may, however, without fear of contradiction, concede to Sedgwick the credit of having been the first to determine the limits and sequence of their larger subdivisions, and to Murchison and his followers the honour of having been the first to assign them their distinctive fossils. Sedgwick worked out single-handed the true stratigraphical arrangement of the rocks of the Lower Palæozoics of Wales, from the Bangor Beds to the summit of the Bala Series, and divided them into several successive groups, the propriety and convenience of which subsequent research has served only to make more distinctly apparent. The unavoidable—but none the less vital—defect in his earlier work lay in his not publishing the characteristic fossils of these subdivisions, until after the appearance of the great work of his rival, in which the most conspicuous forms appear as characteristic of the subdivisions of a supposed overlying system. Murchison's work, on the other hand, depended not only upon mineralogical characters and sequence of formations, but also upon palæontological peculiarities. He failed signally, however, in strictly and correctly defining his lower groups, and in correlating some of his most typical beds, with the result of greatly confusing his lists of characteristic fossils.

The rigid conservatism of Murchison in his old age, and his systematic disregard of the facts and arguments adduced in support of the Cambrian System, brought about its inevitable re-action after his death. The campaign against the Murchisonian nomenclature, so brilliantly opened by Professor Sterry Hunt, in his masterly paper on the "History of the Names Cambrian and Silurian in Geology," has since assumed extraordinary proportions. The Cambridge School, headed by Professor Hughes, the present talented occupant of the Woodwardian Chair, supported by several earnest and industrious adherents, has revived the claims of Sedgwick in all their entirety; and presses them on the attention of geologists with an energy and persistence that threatens to lead to the formation of a body of workers, determined to force from posterity, in honour of the memory of Sedgwick, the rights he demanded, but of which during his life-time he was so unfairly deprived.

But, on the other hand, the Murchisonian nomenclature is embodied in the maps and publications of the National Survey. It is embalmed in the classic memoirs of the illustrious Barrande, and in the numerous works of the best-known geologists of Europe and America. It is still held, almost in its widest sense, by the more influential officers of the Geological Survey, and is taught to their students and sub-ordinates with that complacent pride which has naturally been engendered by a quarter of a century of uninterrupted success. Even yet, its advocates have such an unfaltering faith in its intrinsic propriety and consequent impregnability, that the fact of the daily increasing number and ability of their opponents is either contemptuously ignored, or, at most, is deemed unworthy of a more respectful recognition than a passing smile.

The utter impossibility of reconciling the antagonistic claims of these opposing schools has led, of late years, to the formation of a third party, in which the best-known names are those of the late Sir Charles Lyell, and of Dr. Henry Hicks. These concede the light of Murchison to all the strata between the base of the Arenig and the summit of the Ludlow, but emphatically assign the Lingula Flags and Paradoxides Beds to the Cambrian. This school—if school it may be called—has been greatly aided by the wide publicity given to their views in the numerous memoirs in which they record their steady and cautious advance in working out the natural succession among the subordinate members of the Lower Palæozoic Rocks. It is just possible that, owing to the modesty of the claims it makes for Sedgwick, and to its retention of such a large proportion of the prevalent nomenclature, this view might gradually and insensibly have taken possession of much of the field, were it not for the persistent exertions of the Cambridge School, smarting under a sense of injustice, and determined to rest satisfied with nothing less than a complete redress of those historic grievances, which their affection for the honoured name of Sedgwick has led them to regard as little less than personal to themselves.

But the partial success that has already attended the earnest conscientiousness and perseverance of the members of the Sedgwickian party has, in truth, hastened the evil day. The result that their efforts have had in calling the attention of geologists to the salient points of the question at issue, is as fatal in its effects upon their own theory, as it is upon that of their opponents. By their recent adoption of the Lyell-Hicks line of demarcation at the base of the Lower Llandovery, they furnish, indeed, a thorough demonstration of the almost perfect palæontological distinctness of the faunas of the so-called *Lower Silurian* formations, and those of the true or Upper Silurian, and the consequent impossibility of combining them philosophically in one and the same system. But, in spite of all that is implied to the contrary, this course is, in effect, a distinct abandonment of Sedgwick's fundamental argument that these systems were necessarily distinct, from the fact that in the typical areas their beds were stratigraphically discordant. It amounts, on the other hand, to an implicit adoption of the only safe principle, that we have no reliable chronological scale in geology but such as is afforded by the relative magnitude of zoological change—in other words, that the geological duration and importance of any system is in strict proportion to the comparative magnitude and distinctness of its collective fauna. It appears to me that it is impossible for them to rest here, but that their next and inevitable step will be the further admission that the Lyell-Hicks division of *Cambrian* and *Lower Silurian* are as rightly entitled to the rank of separate systems as the true or *Upper Silurian* itself; and that, eventually, their rigid sense of fairness and justice will lead them so to discriminate them.

For, amid all the confusion incident to this controversy, one grand fact stands out clear and patent to the most superficial student of Palæozoic geology — namely :— the strata included between the horizon marking the advent of *Paradoxides,* and the provisional line presently drawn at the summit of the Ludlow, imbed *three distinct faunas,* as broadly marked in their characteristic features as any of those typical of the accepted systems of a later age.

The necessity for a tripartite grouping of the Lower Palæozoic Rocks and Fossils, in partial accordance with this fact, has been very generally acknowledged for the last thirty years. The keen-eyed and philosophic Barrande was the first to recognize this truth, and his addition of the "*Primordial*" to the *First* and *Second* Faunas of Murchison's original Silurian marked a geologic era equal in importance to the establishment of a new system. How keenly its enthusiastic discoverer watched over, and how zealously he promoted and encouraged, the gradual detection and elimination of his "*Primordial*" Fauna in Europe and America, are matters familiar and delightful to all earnest students of the history of discovery among the Lower Palæozoic Rocks. How the facts obtained by Phillips, Salter, and Hicks in Britain, forced even Murchison himself to adopt Barrande's views, and in his later years to become their keenest and most unsparing advocate, is equally well known. The subsequent development of the "*Primordial*" Fauna in Britain by Hicks, Salter, Belt, and others; in Sweden by Angelin, Nathorst Linnarsson, and Sjögren; and in America by Billings, Emmons, Hall, and Hartt, has progressed with marvellous rapidity. Every systematic geologist worthy of the name has, in his turn, been compelled to acknowledge the distinctness and first-rate importance of the "*Primordial*" Fauna.

Under one form or another, also, the difference in the facies of the more recent *First* and *Second* Faunas of Murchison has been universally admitted from the first, and the rock-groups formed by their including strata have been separated—at least as distinct *sub-systems*—in all parts of the world. It is indeed true that there have been, perhaps, as many diverse views held with respect to the proper position of the line of demarcation between them, as there have been separate areas of investigation; and it is only of late that geologists have reached something like a concensus of opinion in drawing it with Hicks at the base of the Lower Llandovery. Nevertheless, no honest investigator, either British or foreign, has ever dreamt of disputing the grand fact of the distinctness of these two faunas and the consequent need for the separation of their containing rock-groups in any natural and workable plan of classification.

Thus, it is hardly possible that any geologist, who is familiar with the rocks and fossils of the Lower Palæozoics, or who is even fairly versed in the literature of the subject, would at present venture to deny the proposition that between the base of the known fossiliferous series and that of the Old Red Sandstone there lie three successive rock-groups—each of which is characterized by a special fauna of first-rate geologic importance.

Further insistence upon this point is probably needless. But if the fact be once admitted, it follows of necessity that the interests of science demand that these three successive rock-systems shall be distinguished by three separate and unmistakable titles.

At this stage, however, we plunge into the very midst of the conflict of the schools. Friends, foes, and spectators, seem all fairly agreed as to the advisability of a triple division of the sediments.

The points around which the strife is at its keenest bear upon the question as to whether these three divisions are of equal classificatory value, and if so, which party has the best right to give them their names.

The strict Murchisonian of the present day claims for the Silurian all the fossiliferous strata that lie between the Archean and the Devonian, and arranges them in his three sub-systems of the *Primordial, Lower,* and *Upper Silurian.* If he is a palæontologist, he seizes at once upon the indisputable fact that the general facies of the fossils of these three divisions, when viewed in their collective aspect, has a marked character of its own, wholly distinct from that of the faunas of the overlying rock-groups. Profoundly impressed by this distinction, the less striking differences between the faunas of the three members of the Lower Palæozoic itself dwindle in his eyes into utter insignificance, and the slightest party bias is sufficient to lead him to regard them with Barrande as forming "one grand and indivisible triad which is the *Silurian System.*" As discovery progresses, gradually demonstrating the former presence of organic existences in strata far below the base-line laid down by the founder of his system, departing gradually in facies from his typical fauna (but, nevertheless, connected therewith by almost imperceptible gradations), his former admission, and the traditions of his school, compel him to keep pace with it, extending his system and fauna downwards step by step. The result is, that if he is consistent, he is at last driven to demand also, with Barrande, the inclusion of the beds which Murchison, even in his latest years, acknowledged to be the very basement rocks of a *pre-Silurian* system.

If, on the other hand, he is a stratigraphist, he instances the fact that in Britain and America no general stratigraphical discordance interrupts the vertical succession of formations between the Archean and the Carboniferous. He points to the Llandovery beds of Britain, and shows that the grandest stratigraphical break in the entire series in the typical area occurs in the heart of a group of beds that the founder of his school placed partly in one sub-system and partly in the other; but which he, in common with all scrupulous geologists, included in a single formation, whose essential unity he fearlessly challenges his opponents to deny. He calls attention to the *Colonies* of Bohemia to show that even where the palæontological distinction between the sub-systems is most abrupt, yet, according to the greatest of Silurian palæontologists, there is actually an alternation of the two faunas in the beds of passage. Or, he points triumphantly to the succession in Scandinavia, where the Lower Palæozoics are reduced to a collective thickness of a few hundreds of feet, and are occasionally folded up and entangled almost inextricably together in a single section, and asks how is it possible to doubt the unity of a System whose members are individually of such insignificant dimensions, and, physically, are so indissolubly united!

The moving principle of the Sedgwickian, on the contrary, is the demand for historic justice. With true British instinct, he recognizes the fact that the revered founder of his school was unfairly deprived of the natural fruits of the labours of a lifetime by the overwhelming forces of influence and circumstance; and he chivalrously devotes all his energies to the task of overturning history to the extent of bringing back matters to the point they would have reached, had the relative position of Sedgwick and Murchison been reversed. To this paramount consideration everything else is sacrificed. The Silurian is cut down so as to include the Upper Division only of Murchison's original System; while all the fossiliferous beds below are assigned to the Cambrian. That in this way he commits precisely the same scientific error as the Murchisonian, never seems to occur to his imagination. That every fact adduced in support of Sedgwick's claim to the rocks of the *Second fauna* can be met by one in Murchison's favour equally cogent, is forgotten. That every error committed by the latter to the destruction of his claims can be paralleled by one equally fatal to those of his opponent, is similarly ignored. He has long since convinced himself of the fact that the Silurian, as he restricts it, is quite large enough to form a system by itself, and that its fauna is grand enough and special enough to characterize one; but we never find him carry out this argument to its legitimate conclusion—that, if so, his own Cambrian is not *one*, but *two* systems, whose individuality he is, by his own principles, equally compelled to recognize. He seeks in all kinds of out-of-the-way spots for evidences of local unconformities between the *Balas* and the *Llandoveries* to satisfy his stratigraphical conscience that there is sometimes an actual physical break between them; when, without leaving his closet, he could assure himself of the fact that the two systems of the so-called Lower and Upper Silurian are already known to be stratigraphically concordant nearly all over the world. Where this argument fails, we find him insisting upon the presence of conglomerates and upon the sudden change in the character of the organic remains. But each and all the principles of classification implied in these distinctions are violated in his own procedure. The grandest zoological breaks in the whole Lower Palæozoic Series (those between the *Olenus* beds and the *Arenigs* of Britain, and between the *Canadian* and *Trentonian* of North America), and the thickest and most persistent conglomerates that antedate those of the Old Red Sandstone (viz. those of the *Lower Girvan* and *Quebec Groups*), all occur in the very heart of his own Cambrian System. Yet of these we hear little or nothing, but all the strata between the Archean and the Llandovery are piled up into a single system, for the sole reason that they happen to occur in association in the mountain-area of North Wales, and were very naturally lumped together by the first scientific man who conscientiously studied them.

The Lyellian is certainly more politic than his excited neighbours, but, from a common-sense point of view, his disinterested procedure is equally unfair. To him, the fact that Murchison described the Upper and Lower Silurian Rocks in his original Silurian System in such a way that they can, to a certain extent, be recognized and identified in Europe and America, is all-weighty. He calls special attention to the fact that Sedgwick's Upper Cambrian was ultimately found to possess the fossils of Murchison's Lower Silurian, but he forgets to add that it was Sedgwick, and not Murchison, who first gave the natural divisions of this group, placing them in their proper relations to each other, and defining their true limits above and below. He points out with emphasis the grand distinctions between the *Primordial* and *Second* Faunas, and the consequent impossibility of uniting the rocks they characterize in one and the same system; but the fact of the stratigraphical break at the base of the Mayhill Sandstone is, however, contemptuously dismissed as of no special classificatory value, and the two Llandoveries are joined in a single formation. Thus, in one stroke, Sedgwick is deprived of his grand argument of a physical break between his own and the overlying rocks; and the *Second* and *Third* Faunas are re-united to form what is termed the Silurian System. In effect, Murchison receives the lion's share, simply on the ground of possession; while Sedgwick is deprived of half his system because he had the misfortune, in the earlier stages of the controversy, not to command so numerous and influential a following as his more socially fortunate opponent.

At irregular intervals, also, we catch a momentary glimpse of a stray individual who refuses to identify himself with either of these great parties; preferring rather to temporize by definitively assigning the rocks of the *Middle Fauna* to neither claimant in particular. He refers to them under such makeshift titles as the *Cambro-Silurian* or *Siluro-Cambrian*, according as his otherwise unexpressed personal bias inclines him to one or other of the contending parties. Occasionally, indeed, we do find him possessed of a true estimate of the grand importance of the group, but he often leaves it to be understood that he regards it as forming a transitional series of second-rate geologic significance; and, in effect, belonging properly to both Cambrian and Silurian at once. He is at the same time so fully impressed with the consciousness of his own forlorn and isolated condition, as well as of the hopelessness of stemming the current of vulgar use and wont, that he generally contents himself with simply recording his protest in this manner, and timidly guards himself against possible ambiguity and misconception by prefixing the qualifying term *True* or *Upper* when he comes to speak of the undisputed Silurian.

But, in addition to the foregoing, there are innumerable outsiders like myself, who care nothing for schools, but everything for the facts. There is that great and ever-increasing body of students who are attracted to the study of geology because of the flood of light it casts upon the mysterious problems of life and its distribution. Above all, there are those foreign geologists, who naturally expect from British investigators an authoritative and unmistakable geologic scale to which to refer the results of their own researches. To all these the crying scandal of this interminable dispute is an annoyance and a positive encumbrance.

But whose procedure shall we follow? Shall we adopt the Murchisonian's convenient plan of carrying down the base-line for the Silurian System as far as a Trilobite has yet been detected, sinking it deeper and deeper into the earth as the progress of discovery reveals the evidence of the former presence of organisms in strata of yet older and older date, at the same time extending its highest boundary upwards into the supra-Ludlow formations as we detect the presence of an occasional fossil of a Ludlow type yet higher and higher in the more rapidly accumulated Red Sandstones above the *Bone beds*, till our unwieldy system includes half the fossiliferous sediments of the globe, and its very subdivisions are almost equal in classificatory importance to the accepted systems of a later date?

Or shall we adopt the methods of the traditional followers of Sedgwick, and, drawing a rigid line of demarcation at the base of the Lower Llandovery, imitate our opponents to the extent of erecting all the anterior fossiliferous strata into a gigantic system, on the ground that they were so combined by its founder, and in the delusive hope that we shall find at its base a universal unconformability, so that the name *Pre-Cambrian* will ever remain a synonym of the metamorphic and possibly azoic formations?

Or, with Lyell, shall we condone the past, and give a double share to the stronger party; consoling ourselves with the reflection that, after all, the question is merely a question of names, and not of principle; arguing that the injustice we tolerate did not originate with us, and is less the crime of a party than the inevitable result of untoward circumstance; and justifying our procedure in the eyes of the world by the implication that the general adoption of the larger portion of the Murchisonian nomenclature is already an accomplished fact, upon which it would be ridiculous to expect that any feeble efforts of ours would ever have the slightest influence?

Or, ought we rather to cast in our lot with the few who employ the term *Cambro-Silurian* or *Siluro-Cambrian* for the rocks of the *Second Fauna*, and try once again the oft-repeated and as oft-defeated experiment of reconciling the claims of both parties by allying the strata in dispute to two systems at once, in the use of titles which their very founders themselves abandoned as inconvenient and absurd?

Or, finally, standing aloof from all parties, shall we, in the name of science, claim the right of fully recognizing the systematic equality of the three Lower Palæozoic Faunas, by regarding the three successive rock-groups which contain them as individually entitled to the rank and denomination of a complete system?

It seems to me that to every unprejudiced mind it will be apparent that the adoption of this last course has now become an absolute necessity. Geologic truth and convenience imperatively demand a separate place and name for each of these systems. It only remains for us so to arrange their titles that no real injustice shall be committed.

Dr. Hicks's definition of the Cambrian system as including the *Paradoxides-* and *Olenus*-bearing beds, from the base of the Harlech Grits to the summit of the Lower Tremadoc is by far the best that has hitherto been proposed. Thus restricted, the title is synonymous with that of the *Rocks of the First or Primordial Fauna* of Barrande, and is certain to be ultimately accepted everywhere among geologists, from its naturalness, geologic distinctness and convenience of application, not only in Britain and Western Europe generally, but also among the ancient rocks of the continent of America.

In the same way the general restriction of the title Silurian to the strata that are comprehended between the line marking the base of the Lower Llandovery, and that denoting the commencement of the brackish or fresh-water conditions of the typical Old Red Sandstone, appears equally inevitable. It covers the whole of the rocks of Barrande's *Third Fauna*, which, as we have seen, must be erected into a separate system as a matter of geologic convenience. It is fortunate that the application of Murchison's title to them has never been disputed, even by his bitterest opponent.

The various titles at present in use for the intermediate system are all certain to be discarded by the geologist of the future. They are all more or less erroneous, ambiguous, or inconvenient. The retention of the designation *Lower Silurian* would be as systematically erroneous as it is historically unjust. To call it *Upper Cambrian* would be to allow the followers of Sedgwick to commit the very error they so emphatically condemn in the procedure of their opponents. The perpetuation of the Sedgwick-Murchison controversy, by the general adoption of such a title as the *Cambro-Silurian* or *Siluro-Cambrian*—even were it possible—would be, to say the least of it, excessively unwise. Neither party is likely to forego its claims when the object of contention is so conspicuously labelled with the names of both.

Before, however, we can take a single step to free ourselves from the present difficulty, we must dispose of two formidable objections, which, under the guise of universally accepted scientific principles, have grown grey in the service of prolonging this unfortunate controversy, and have, as yet, stubbornly barred the way to anything like a peaceful solution.

By those who still retain the Silurian System of the later days of Murchison in all its magnitude, the argument of their founder that there is no universal stratigraphical break to be detected among the Lower Palæozoics, at least as far down as the base of the Lingula Flags, is held to be an overwhelming reply to all objectors. Similarly, it has been the habit for their opponents, in their turn, to point triumphantly to the local breaks in Britain between the Mayhill and Bala beds, as affording in themselves a positive demonstration of the truth of their own view that these formations belong to wholly distinct systems. For a corresponding reason, also, the latter party claims for the Cambrian all the fossiliferous strata that underlie the Llandovery, from the fact that the physical succession among them is uninterrupted by a general physical break. Of such pre-eminent value is this principle considered, even by those who profess to stand aloof from this controversy, that a strong tendency is abroad to sacrifice in its favour the Old Red Sandstone itself.

To the field-geologist, pure and simple, who desires, above all things, an unmistakable base-line for his system, capable of being rigidly defined upon his maps and sections, the presence of a decided unconformability affords the very thing of which he stands most in need. The grouping founded upon stratigraphical breaks commends itself to his mind with a force that is practically irresistible. But it is far otherwise with the cautious systematist, who endeavours to found his systems in accordance with those of Nature herself, upon principles, not of local, but of universal application. Though fully cognizant of the value of an unconformability as affording him a fairly reliable horizon within a limited area, he soon learns that it is of all things most untrustworthy when it extends over regions of large diameter. It is at most a local phenomenon, wholly misleading except in local application.

It is surely a work of supererogation in these days to point out how the tendency of the entire course of geological discovery for the last fifty years has been to reduce to a mere shadow the magnitude of the miraculous and world-wide stratigraphical breaks that bounded the geologic systems of our forefathers. The doctrine of universal convulsion and the simultaneous destruction of all the life upon the earth at the end of each great epoch has so long since passed into the limbo of exploded hypotheses, that it would be highly amusing, were it not so painful, to see its degenerate and impoverished survival—the dogma of the necessity for general stratigraphical and palæontological breaks between our modern systems—dragging out its miserable and ridiculous existence, even in our midst, and claiming allegiance from men of standing in the science.

One concession, and one only, appears to be all that is needful to meet the real facts of the case. As a general rule, our British systems have been founded, less upon palæontological than upon mineralogical considerations, and it is more of the nature of a series of happy accidents, than a geologic necessity, that they happen to possess such distinctive faunas. In all cases, however, it is clear, both here and elsewhere, that the faunas that characterize our accepted rock-systems owe their distinctness—such as it is—to the fact that in the more typical areas there happened to be an absence of fossiliferous strata to unite them. Whether the time thus zoologically unrepresented was occupied in the upheaval and partial denudation of the rocks of the preceding system (as locally between the so-called *Lower* and *Upper Silurians* of Britain), or whether, on the other hand, it was filled by the deposition of barren strata (as between the corresponding systems of the United States), the result is precisely the same. The faunas of the consecutive systems differ to the extent of the progress made in the locally unrepresented interval; and the group of rocks holding each fauna forms for the geologist a convenient Procrustean bed to which to fit the tolerably synchronous deposits of other lands. The unconformability argument is worthless except from the point of view that the faunas of our typical British systems are likely to be the more distinct the longer these separating interregnums lasted. It is best, that is, simply as a matter of convenience and clearness of definition, to choose, if possible, the longest non-fossiliferous periods to divide them, and these are almost certain to occur where there is the greatest appearance of unconformability.

Nevertheless, the same effect may be owing to a cause in its nature diametrically opposite—the required palæontological break being due to a more than ordinary depression of the sea-bed, and the consequent cessation of almost all deposition in that area—a circumstance to my mind of equal importance from a classificatory point of view with an unconformability itself. An extraordinary regional depression of this character seems to have been the actual cause of the apparently sudden change in the facies of the Palæozoic fauna at the commencement of the Arenig period, both in Britain and Scandinavia, and when fully worked out will, in all probability, enable us to lay down a palæontological line of demarcation far more strictly synchronous throughout its geographical range than that which we shall be compelled to adopt at the base of the Lower Llandovery.

Nor is the venerable objection—that, owing to the established laws of scientific nomenclature, a moral obligation is binding upon us to adhere rigidly to the limits of each system as originally laid down by its founder—worthy of a whit more respect.

This is a claim whose absurdity verges upon the ridiculous when it is advanced by the Murchisonian in support of his contention that the *Paradoxides and Olenus* beds appertain to the Silurian, for they actually antedate all the strata of Murchison's original *Silurian System.* It is, therefore, only occasionally employed by him in a restricted sense in defence of his retention of the strata of the *Second Fauna.*

It crops up continually, however, in the writings and arguments of those belonging to the opposite party. It is urged again and again with a wearisome iteration, as if this conservative rule in geologic nomenclature were necessarily to over-ride every other scientific canon whatsoever. But even if we grant that Sedgwick, and not Murchison, first correctly defined and characterized the rock-group which yields the *Second Fauna,* this rule is equally inoperative in the face of our present recognition of the grand geological importance and distinctness of this *Fauna.* Of this fact Sedgwick was originally wholly unaware; nor does he ever appear to have estimated it at its true value. To us, however, who have watched the gradual elimination of the *Primordial Fauna,* the grand distinctness of the *Second Fauna* is so glaringly apparent, that it is impossible for us to conceive of the rock-group which it characterizes as a mere subdivision of the Cambrian.

It is all very well to plead for historic justice, and to demand, out of respect to the memory of a genius, the adoption of the nomenclature which the general geological world was, in a sense, deprived of the opportunity of accepting during his lifetime. But time and geological convenience will soon make short work of any scheme of nomenclature, however historically just, if it be not in all its parts the natural expression of the inter-relationships and mutual subordination of the facts it is its special aim to associate and systematize.

No amount of enthusiastic regard for the memory of a martyr will bolster up an unwieldy system for ever. The giant size upon which its weaker advocates pride themselves must in the end be the main cause of its inevitable dismemberment. We shall best promote the interest of the man whose memory we venerate, by modestly claiming for him as much, and no more, than truth and geological convenience will allow.

Thus, however reluctant we may be to interfere with the schemes of classification propounded by our great masters in the science, it appears to me that the time has now arrived when we can no longer be accused of disrespect or disloyalty in endeavouring to emancipate ourselves from the inconveniences due to our superstitious adherence to an effete and unworkable nomenclature. The present needs of our science demand, with a unanimous voice that partizanship can no longer silence, a distinct title for the rocks of the *Second Fauna.* The experiment of naming them in such a way as to recognize the claims of both Murchison and Sedgwick has been tried again and again with the same result. It has invariably ended in prolonging and greatly intensifying the original controversy. But one course remains to us. We must give it a new title, which, though it might have been originally suggested by either party, shall contain no element of future discussion.

So long as present systems of nomenclature survive, nothing can disturb the application of the title of Cambrian to the rocks of the *Primordial Series,* and that of Silurian to the strata of the *Third Fauna.* In these systems, as thus restricted, the most perversely ingenious partisan could scarcely find room for controversy. Within these limits the labours of their respective founders were comparatively perfect and complete, and the propriety and harmony of their original classifications, though slightly modified in detail by subsequent research, has never been impugned, either by friend or foe. It is vastly different, however, as we have seen, with the intermediate system. From the day it was recognized until now, it has been the object of incessant disputes. Its co-discoverers both committed the gravest of errors regarding either its proper limits, its relationships, or the sequence and fossils of its component formations. It has been the subject of almost as much passionate argument as the Wernerian theory itself; and the whole subject is a disgrace to modern science, and an obstacle to its progress that must be got rid of—whatever the sacrifice.

Time has already done justice to the value of the discoveries of both Murchison and Sedgwick, by assigning them each a system in which their labours were accurate and complete. We shall do their memories the greatest service by giving the system in which their work appears to our eyes—in the light of later discovery—to have been more or less inaccurate or deficient, a title which shall bear no personal reference to either.

Sedgwick, with his well-balanced and philosophic mind, named his system after the entire Principality in which his rocks were typically developed. His title of Cambrian is thus comprehensive enough to embrace the whole of the Lower Palæozoics. It not only calls up before the imagination the majestic mountains where they may be studied under their most typical aspect, but it reminds us that they formed the fortress-homes of the early Britons—those proud old savages, who, like the *Greywackés* upon which they trod, were the last to succumb to the irresistible march of conquest.

Murchison, on the other hand, with his military proclivities, and a keener instinct for locality, had already made choice of the term Silurian; associating the rocks of his system with that classic Cambrian tribe, the *Silures*, whose indomitable struggles for liberty had hallowed the very hills upon which he sought his types; and thus, in a measure, he may be said to have erected an everlasting monument to British valour and love of freedom.

But, as has been more than once pointed out elsewhere, the *Silures* were a nation inhabiting the *southern* parts of Wales, and Murchison distinctly availed himself of the privileges of genius in thus extending their rule into Shropshire and the regions to the *north.*

North Wales itself—at all events the whole of the great Bala district where Sedgwick first worked out the physical succession among the rocks of the intermediate or so-called *Upper Cambrian* or *Lower Silurian* system; and in all probability much of the Shelve and the Caradoc area, whence Murchison first published its distinctive fossils—lay within the territory of the *Ordovices;* a tribe as undaunted in its resistance to the Romans as the Silures. It was indeed the *last* of the old British tribes to yield to their invincible legions; and it is consequently quite as well worthy of scientific commemoration as the Silures themselves.

Camden thus refers to the Ordovices:[1] "Those countries of the *Silures* and *Dimetæ*, which we have last surveyed, were in after-times, when Wales came to be divided into three Principalities, called by the natives Deheubarth (or the Right-hand part), and in English, as we have already observed, South Wales. The other two Principalities (which they call Gwynedh and Powys, and we North Wales and Powisland) were inhabited by *the Ordovices*, called also *Ordevices*, and *Ordovicæ*, and in some authors, though corruptly, *Ordulucæ*. A courageous and puissant Nation these were, as being inhabitants of a mountainous country; and receiving vigour from native soil; and who continued, the longest of any, unconquered either by Romans or English. For they were not subdued by the Romans till the time of the Emperor Domitian; when Julius Agricola subdued almost the whole nation. Nor were they subjected by the English, before the reign of Edward the First. For a long time they enjoyed their liberty, confiding as well in their own strength and courage, as in the roughness and difficult situation of their country, which seems to be laid out by Nature for ambuscades and the prolongation of war. To determine the limits of these *Ordevices* is no hard task, but to give a true reason of the name seems very difficult. However, I have entertained a notion, that, seeing they were seated upon the two rivers of Devi, which springing

[1] Camden's *Britannia*, Dr. Gibson's Translation, second edition, p. 778.

not far asunder, take their course different ways, and that *Oardevi* (Read *Ar-dhyvi*—Transl.) in the British language signifies—Upon the rivers of Devi—they have been thence called *Ordevices.* To the *Ordovices* belonged those countries which are now called in English by new names—Montgomeryshire, Merionethshire, Caernarvonshire, Denbighshire, and Flintshire."

Here, then, have we the hint for the appropriate title for the central system of the Lower Palæozoics. It should be called the Ordovician System, after the name of this old British tribe.

Whatever arguments may be adduced in support of the term Silurian will apply equally well, or even with greater force, to this new title. Like the term Silurian, it is classic in origin, but at the same time thoroughly British. It is equally euphonious, and far more strictly significant of the geographical area where its strata are typically developed. Indeed, the employment of the one title almost of itself necessitates the adoption of the other; for only in this way is it possible to recognize the systematic equality of the two systems in their very designations—the one receiving its name from the ruling tribe in the *south* of Wales, the other from the dominant tribe in the *north.* If there is anything specially becoming in commemorating the warlike tribe of the Silures in the name of a geologic system, how strikingly appropriate is the title of *Ordovician* in erecting a similar scientific monument to the last and most valiant of the old Cambrian tribes.

On this arrangement the Lower Palæozoic Rocks of Britain stand as follows:—

(*c*) Silurian System:—Strata comprehended between the base of the *Old Red Sandstone* and that of the *Lower Llandovery.*

(*b*) Ordovician System:—Strata included between the base of the *Lower Llandovery* formation and that of the *Lower Arenig.*

(*a*) Cambrian System:—Strata included between the base of the *Lower Arenig* formation and that of the *Harlech Grits.*

That our attempt to cut in this way the knot which all the schools have already convinced both themselves and others of the utter impossibility of untying, will do much more than draw the attention of geologists in general to what we believe to be the more striking aspects of the question, can hardly be expected. It is almost certain that any suggestion that might have been made by either of the schools with the object of freeing this section of the science from the present dead-lock, would, as a matter of course, be opposed to the utmost by the others. How much worse is it when the hint is given from without. The great mass of the most influential of our living geologists have so long since given in their adhesion to one or other of the contending parties, that it is not improbable that our well-meant interference will be stigmatized by all as a most unwarranted and impertinent intrusion.

By those, however, who are weary of the interminable discussion, and who feel the necessity for some scheme of classification which, while it systematizes the known facts, holds the balance true with reference to the opposing claims of the two great pioneers in the study of the Lower Palæozoics, our suggestion may be tolerated now, and adopted later on, when the necessity for this course has become more strikingly apparent. To those who interest themselves in the attempted correlation of the Lower Palæozoic Rocks of the Northern Hemisphere, and who are continually hampered by the want of some clear and unmistakable generic terms expressive of the general parallelism among these widely-separated deposits, the ease and comfort of a classification which imitates Nature herself in placing the three grand members of the Lower Palæozoic Rocks upon an equal footing, is an advantage of which they are certain in time to avail themselves to the full. Those again, who feel how vain is the endeavour to parallel the special formations and minor stages of our British Lower Palæozoics with those of other areas, will hail with some approach to satisfaction the release of such convenient sub-generic terms as *Lower* and *Upper Cambrian*, and *Lower, Middle, and Upper Silurian*, with the list completed by the addition of *Lower* and *Upper Ordovician*;—terms all of easy and immediate application, and all expressive of epochs, which, so far as our present knowledge enables us to judge, embrace tolerably equal periods of geological time.

No earnest student of the history of discovery among the Lower Palæozoic Rocks, whose opinions are the natural outcome of his own careful generalization of presently known facts, and not the petrified remains of the views he so enthusiastically adopted a quarter of a century ago, can fail to perceive that the ideas of the extreme party which claims all the Lower Palæozoics for the Silurian are fated soon to become wholly extinct. The wave of backward opinion which led this party to revert in substance to the ideas of their predecessors was inevitable. We are now witnessing the as-inevitable return of the tide. Here and there this application of the term may linger on for a time, as in Bohemia, and possibly in Scandinavia, kept alive by the very principle that must in the end prove fatal to it, when local conveniences become superseded by cosmopolitan necessities.

A single glance at the magnificent development of the Lower Palæozoics on the continent of North America is enough to convince every unbiassed investigator how much we have yet to learn regarding their British prototypes, and how ridiculously inadequate is our present estimate of their grand importance in the geological series. As this knowledge dawns upon us as the result of our discoveries in the future, some such classification as is here proposed will perforce be adopted by all; and the systematist will then be left free to work out his generalizations untrammelled by the defects of a cramped and unnatural nomenclature. Our British strata can in the end return but one answer to the most extended appeal. Every geologist will at last be driven to the same conclusion that Nature has distributed our Lower Palæozoic Rocks in three sub-equal systems, and that history, circumstance, and geologic convenience, have so arranged matters that the title here proposed for the central system is the only one possible.

II.—On the Volcanos of the Bay of Bengal.

By V. Ball, M.A., F.G.S.;
of the Geological Survey of India.

(PLATE I.)

During the year 1873, it was my good fortune to be one of a party who, in the course of an exploration of the Andaman and Nicobar Islands, were enabled to spend a few hours on the detached volcanic islands of the Bay of Bengal, which are known respectively as Barren Island and Narkondam. The time at our disposal did not admit of our making as thorough an examination as we should have wished, but there was sufficient opportunity for testing the accuracy of the statements regarding the islands which had been previously published, and also for making a few original observations.

The information upon which the accounts of Barren Island, given in geological manuals and other works, have been founded, is exceedingly faulty. Dr. Liebig's paper, which contains the fullest and most accurate description of the island, does not appear to have reached the hands of several authors, who have since its publication tenaciously clung to old statements which should have been long since expunged.

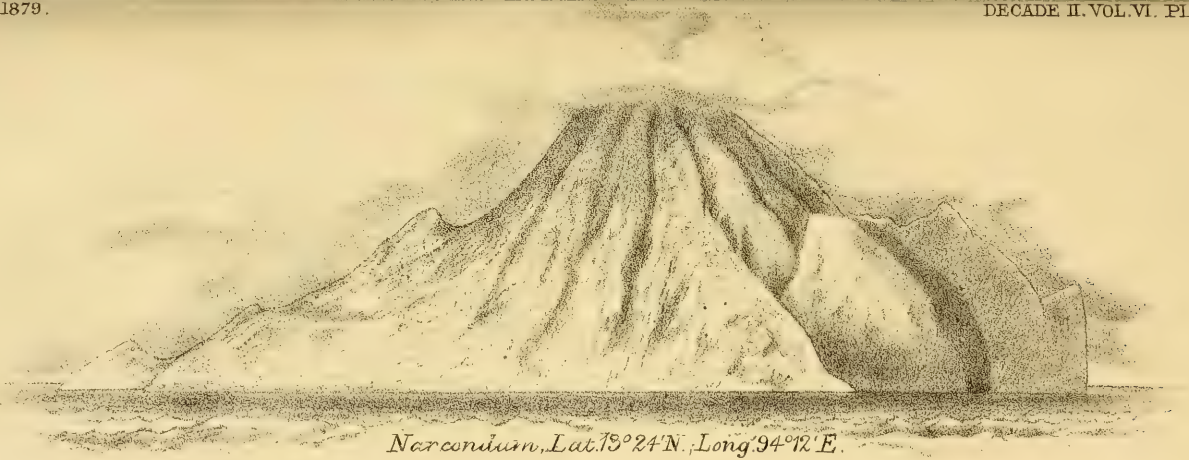
In presenting this account to the readers of the Geological Magazine, it is necessary for me to premise that in substance it has already been published in the Records of the Geological Survey of India.[1] The present edition differs from the original in being illustrated by the accompanying sketches of the islands, and in sundry small alterations and additions to the text.

The wide circulation of the Geological Magazine among geologists throughout the world affords an unequalled opportunity for stamping out errors like those which are exposed in the following pages. It is hoped that in future works and editions of works on Geology or Volcanos there will be no repetition of the old statements or old illustrations which have served to give such incorrect ideas as to the physical features of these remarkable islands.

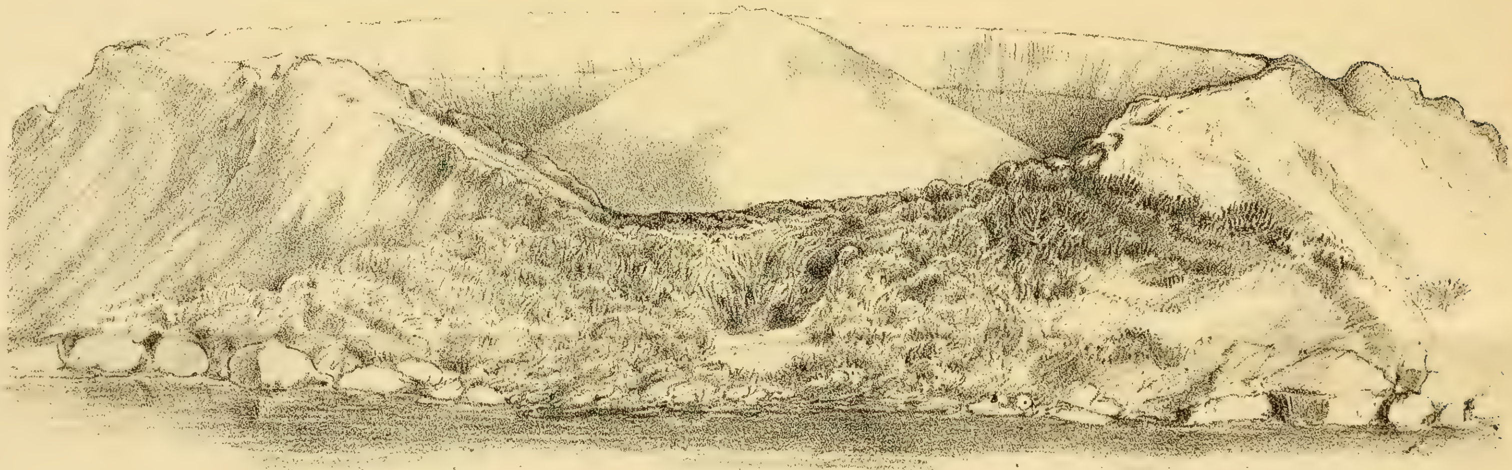
Barren Island and Narkondam are two volcanic islands situated in the Bay of Bengal at a distance of seventy miles from one another on a north-by-east, south-by-west line. They constitute links which connect what is known as the Molucca band with the volcanic region of Arracan and Chittagong. This has been pointed out by several physical geographers, one of whom[2] has written :—

"One of the most terribly active groups of volcanos in the world begins with the Banda groups of islands, and extends through the Sunda groups of Timor, Sumbawa, Bali, Java, and Sumatra, separated only by narrow channels, and altogether forming a gently curved line 2,000 miles long; but as the volcanic zone is continued through Barren Island and Narkondam in the Bay of Bengal, and

[1] Calcutta, No. 4, 1873. [2] Mrs. Somerville.



Narcondum, Lat. 13° 24′ N., Long. 94° 12′ E.



Bird's-eye view of Barren Island, Lat. 12° 17′ N. Long. 93° 54′ E.

A.S. Foord lith. West, Newman & Co. imp.

northward along the Coast of Arracan,[1] the entire length of the volcanic range is a great deal more."

Dr. Hochstetter carries the line of elevations which accompanies the zone of volcanic action still further, in an oblique S form, through New Guinea to the north of the Australian continent. "It forms in New Ireland, the Solomon Islands, New Hebrides, and New Zealand, a curve, concave towards the west, the small group of the Macquarie Islands being possibly considered as the extreme southern end of this curve."

So far as is known, there are no volcanos in either the Nicobar or Andaman Islands. It has been by some supposed that the hill on Bompoka in the Nicobars, and some of the high ground in the Great Nicobar, might be volcanic, but the evidence is rather against than in favour of this view. Igneous rocks (diorite and gabbro) not unfrequently occur, however, in both groups of islands. A statement made in an old account of the Cocos, that the little Coco is formed of volcanic rocks, is, I believe, quite without foundation. The only rocks I observed there were Tertiary sandstones and shales.

Barren Island, Lat. 12° 17′ N.; Long. 93° 54′ E.

History of the Island derived from Previous Notices.—In the table appended I have given a *précis* of all that has been published on the subject of Barren Island; but a few additional remarks, tracing out the way in which certain inaccuracies have arisen, seem to be desirable.

The first published account was by Captain Blair, in his report on the Andaman Islands, dated 1789. I have not seen the original document, but the account was extracted and reprinted by Lieutenant Colebrooke in the Asiatic Researches.

Captain Blair gave the height of the central cone at "nearly 1,800 feet." Were it not also stated, however, that the cone was equal in height to the outer walls of the surrounding part of the island, we might, in consequence of Blair's oft-proved accuracy as an observer, be disposed to believe that at the time of his observation the cone was nearly double its present height. That there has not been a general subsidence of the island to the extent of 800 feet is proved by the fact that the base of the cone was then, as it is now, but little raised above the sea-level. Blair himself states that the island may be seen at a distance of twelve leagues in clear weather, which would only require an elevation of about 920 feet. I can only suppose, as an explanation of the difficulty, that Blair took several heights which varied between 800 and 1,000 feet, and that these, by some error, came to be written together as 1,800.

The angle of inclination of the sides of the cone is stated by Blair to be 32° 17′.

The sketch by Lieutenant Wales given in Lieutenant Colebrooke's paper, save that it represents an inclination of about 60° for the sides of the cone, conveys the best idea of the island of any of the

[1] A very full account of the mud volcanos on this coast has recently been published by Mr. F. R. Mallet, F.G.S., Rec. Geol. Survey of India, vol. xi. part ii. p. 188.

numerous figures which have been published. It was reproduced by Von Buch, and copied from him by Sir Charles Lyell, Dr. Daubeny, Dr. Buist, Von Cotta, etc. Von Buch, in his "Memoir on the Canary Islands," gives the height of the cone at 1,690 Paris feet. His account, though apparently derived from Lieutenant Colebrooke's paper alone, contains the statement that *the sea penetrates into the circle at the base of the cone.* This can only have been due to some misapprehension of the meaning of Blair's words, which were as follow:—"The base of the cone is the lowest part of the island, and very little higher than the level of the sea."

Sir Charles Lyell, in the earlier editions of the "Principles," framed his account from Von Buch's. In the changes from English into French, and back again into English, the elevation of the cone became increased by 48 feet, standing in the seventh edition of the "Principles" (1847) at 1,848 feet. It is also there stated that the circular basin inside is filled with the waters of the sea. In the ninth edition (1853), Captain Miller's estimated elevation of 500 feet is adopted instead of the former one; but the statement regarding the sea inside still remains. In the tenth edition (1868) Captain Miller's estimate of 500 feet, as the height in 1834, is retained; but it is stated that according to Von Liebig in 1857, both the cone and outer crater were about 1,000 feet high, and in reference to the sea we find the following:—"In some of the older accounts the sea is described as entering the inner basin, but Von Liebig says it was excluded at the time of his visit." I believe this statement regarding the sea to have arisen solely in the way I have pointed out. It is important that there should be a clear representation of the case, as otherwise it might be concluded that we have direct evidence of the rising of the island within the historical period.

The next account to that by Blair is by Horsburgh, about which there is nothing particular to remark here, save that he asserts that in 1803 the volcano was very active (see table).

Dr. J. Adam's account is derived from information and specimens received from a friend who had landed on the island in 1832. He speaks of the stones on shore hissing and smoking, and the water bubbling all round them. The statement has apparently been understood by one writer to indicate that the lava at the surface had not then cooled down. But the hot spring was probably quite sufficient to account for the phenomena observed. This is the first mention made of the hot spring. The author supposes that the volcano is only active in the south-west monsoon,[1] *i.e.* requires water to bring it into a state of activity. Apart from other considerations, it is only necessary to say that the only authentic account of it in a really violent state of eruption is by Blair, who saw it on the 21st of March, and therefore not during the south-west monsoon.

Captain Miller's account is very inaccurate in several respects. He has given the height at 500 feet, and the angle at which the cone

[1] Curiously enough Mr. Mallet (*l.c.*) mentions that a similar belief is held by the islanders with regard to the activity of the mud volcanos of Ramri and Cheduba, but he points out that the recorded dates of eruption do not support this view.

rises at 45° or even more. If the elevation of the cone in his time were only so much, then, since he states that this was also the elevation of the outer walls or amphitheatre, both must have increased *pari passu.* This view is of course untenable, and we are forced to believe that Captain Miller only gave a rough guess. His remarks on the vegetation are quite inconsistent with one another, for he says,—"There is no vegetation of any kind within the amphitheatre, but *a few small trees* are found on other parts of the island, which, however barren it may have been at one time, is *now well wooded.*"

Dr. Daubeny, in his description of Barren Island, though quoting from Lieutenant Colebrooke, gives the elevation of the cone at 4,000 feet, which must, I think, have been due to a clerical error. A somewhat modified reproduction of the original sketch is given.

Mr. Scrope, in his work on Volcanos (2nd edition, Lond., 1862), writes regarding Barren Island: "This permanently active volcano is a cone about 4,000 feet high, rising in the centre of a circular cliff range, which entirely surrounds it except at one point where the sea has broken in." Though the authority is not given, it seems probable that this account is derived from Dr. Daubeney's, as the elevation is not given at 4,000 feet in any other work.

In 1846 the island appears to have been visited by the Danish corvette *Galathea,* but the only record of the fact is said to be an inscription on a rock on the island—"GALATHEA, 1846." This we failed to observe.

In the *Bombay Times* for July, 1852, on the authority of Dr. Buist, it is stated that the volcano was then very active, but I have not been able to refer to the original account.

The chief points in the accounts subsequent to the above will be found incorporated below (see the table on pp. 20, 21). Dr. Playfair, Von Liebig, and the Andaman Committee agree in estimating the angle of the cone at 40° to 45°, and the elevation at from 975 to 980 feet.

From the preceding records we may gather the following. The volcano has probably not been in violent eruption since the years which closed the last and commenced the present century.[1] The lava-flow which stretches from the entrance open to the sea to the base of the cone was probably poured out during this period, and raised the level of the encircling valley some 40 feet above its elevation in 1789, when Blair saw it. He makes no mention of a lava-stream in his time. If it did not exist then, it cannot—as has been supposed by some—have been instrumental in the formation of the entrance. That this fissure was probably due to other causes we shall presently see.

From Lieutenant Wales' figure it is apparent that no material change has taken place in the general configuration, and as it has been shown that 1,800 feet cannot have been the true height, and about 920 probably was, no great alteration in the elevation is likely to have taken place.

[1] The statement "very active" from the *Bombay Times* is too vague for reliance.

ABSTRACT OF THE PUBLISHED ACCOUNTS OF BARREN ISLAND.

Year.	Authority.	State of Activity.	Slope of Cone.	Elevation.	Temperature of Hot Spring.	Condition of Vegetation.	References.
1787	Colebrooke	A column of smoke arising from the summit visible 7 leagues off	....	....	....	....	Asiatic Researches, vol. iv. 1795, p. 397, fig.
1789	Blair	In a violent state of eruption, bursting out immense volumes of smoke, and frequently showers of red-hot stones, weighing 3 or 4 tons	32°17′	1,800	....	Parts remote from the cone covered with withered shrubs and blasted trees	Report on the Survey of the Andamans, and Asiatic Researches, *l. c.*
1791	Horsburgh	A quantity of very white smoke close to the crater	....	....	....	....	Horsburgh's India Directory, 5th edition, vol. ii. 1843, p. 55
1801	Almes	....	....	....	....	Firewood could be got with difficulty	
1803	Horsburgh	Exploded regularly every ten minutes, projecting each time a column of black smoke perpendicularly to a great height. In the night a fire of considerable size continued to burn on the east side of the crater					
1832	Dr. J. Adam's friend	Large volumes of thin white smoke continually issuing	....	½ a mile =2,640ft.	Almost boiling	Small shrubs scattered about on the S.W. side	J. A. S. B., vol. i. 1832, p. 128
1836	*Von Buch*	Account same as in Asiatic Researches, with some variation	....	1,690 Fnch. feet	....	....	Description Physique des Iles Canaries, etc., Paris, 1836, p. 431, Atlas Plate vi.
1840	*Sir C. Lyell**	Account founded on Von Buch's	....	1,848	....	....	Principles, 6th edition, 1840, vol. ii. p. 286, also in 7th edition

1843	Capt. Miller	A clear full stream of transparent vapour	45°	Upwards of 500	....	No vegetation within the amphitheatre, but other parts are well wooded	Account drawn up by Dr. McClelland, Calc. Journ. Nat. Hist., vol. iii. 1843, p. 422
1846	"Galathea"	....	....	....	....	....	Is there any published record of this visit?
1848	*Dr. Daubeny*	Founded on Blair's account	....	4,000 !	....	....	Daubeny on Volcanos, London, 1848, p. 413
1851	*Mrs. Somerville*	No details	....	....	....	....	Physical Geography
1852	*Dr. Buist*	Quotes previous accounts					
1852	"Bombay Times"	Very active	....	....	....	....	"Bombay Times," July, 1852
1857	Dr. Liebig	Clouds of white vapour issued from fissures near the summit	40°	980	104° F.? Almost boiling	Shrubby patches on the slopes towards the sea	Zeitschrift der Geolog. Gesellschaft, vol. x. 1858, p. 302; also in Rec. Govt. of India, xxv. 1859, p. 124; J. A. S. B., xxix. 1860, p. 1; and in Mouat's Adventures and Researches
1857	Dr. Playfair and Lieut. Heathcote	Smoke issued occasionally from a little below the summit	40°	975	140° F.?	Not mentioned	Rec. Govt. of India, xxv. 1859, pp. 121–123
1862	*G. Poulett Scrope*	Account same as that by Dr. Daubeny	....	4,000	....	....	Volcanos, by G. P. Scrope, M.P., London, 1862, pp. 199 and 468
1866	Andaman Committee	A whitish vapour was evolved from several deep fissures	40°	980	158°–163°	No trees of any height, but on the slopes and ridges are abundance of shrubs, some rising to twenty feet	Report on Barren Island, P. A. S. B., October, 1866, p. 212

* For changes in subsequent editions, see page 18.

The names of authorities whose descriptions are not derived from personal observation are given in italics.

General Description of Barren Island.—Seen from any side but the north-west, Barren Island appears as a nearly flat-topped hill with numerous spurs running down into the sea. From some aspects, however, the top of a central cone with a column of smoke rising from it is discernible.

As the north-west side opens up to view, it is first realized that the island consists of a circular ridge forming a huge amphitheatre, which is broken down at one side for a distance of perhaps 150 yards to the level of the sea. The view obtainable through this entrance discloses a bare cone which rises from the centre of the island. Except at a sort of shoulder not far from the top, and at two peaks close to the summit, no rocks are seen on this cone, its smooth sides being covered with grey ash and occasional strings of shingle. Towards the top some whitish patches are seen, these are due to the presence of gypsum mixed with the ash.

The accompanying illustration, it will be observed, is somewhat diagrammatic in its character, being rather of the nature of a bird's-eye view, than a representation taken from an actual point of view.

The total diameter of the island is, on the authority of Lieutenant Heathcote, 2,970 yards. The circuit of the island, from the time it took us to row round, I estimated at about six miles.

The high encircling ridge is formed of somewhat irregularly deposited layers of lava, ash, and conglomerate, which dip away from the centre. A section of these may be seen on the left hand of the gap or entrance, and others at various points on the sea-face, no two of them corresponding exactly in character.

These beds or layers generally dip at angles of 35° to 40°, which inclination appears to be continued steadily under the sea, as bottom, except at one place, has not been found with a line of 150 fathoms at one-quarter of a mile from the shore. This steepness has been unfavourable to the formation of a fringing reef of coral of any magnitude, such as we find surrounding some of the islands of the Andaman and Nicobar groups. The elevation of this outer ridge varies somewhat in places, but it probably nowhere is much in excess of 1,000 feet. Its highest points are towards the south and west.

The appearance presented by the inner scarped face of this amphitheatre is very peculiar. In several places cornice lines mark the position of particular beds, but a purplish grey, or in places brownish, ash spreads over the steep slopes, except towards the south-west and west, where there are some trees and shrubby vegetation. To the north, south, and east a few tufts of grass—generally arranged in long vertical lines, the first being a sort of protection to those below it—are the only plants which have managed to establish a footing in the loose ash. The outer slopes facing the sea are for the most part covered with a luxuriant vegetation, in which large forest trees may be discerned. These latter attract considerable numbers of fruit-eating pigeons (*Carpophaga bicolor*).

From its composition and character, it is evident that this ring of cliffs is the remnant of the original cone which gradually rises from below the sea. Its top and a portion of the side were, no doubt, blown off by a violent eruption, and the present cone was subsequently formed inside. The gap or fissure in the surrounding walls bears about north-west-by-west from the centre of the island. It is the only place where an entrance can be obtained to the central valley.

For a long time Barren Island was considered by Von Buch and others of his school as a most favourable example of his elevation theory of craters. Since, however, the island is in reality only formed of volcanic materials elevated above the sea without a trace of any pre-existing rocks, it is evident that its peculiar form gives no support to that now exploded hypothesis.

Hot Spring.—Close to the landing-place, there is a hot spring which has been mentioned in several of the accounts of the island. Dr. Playfair found the temperature to exceed 140°,—the limit of his thermometer. Dr. Liebig's thermometer was only graduated up to 104°, but judging from the feel to the hands, he estimated it to be near the boiling-point. The Andaman Committee record it at from 158° to 163°. At the time of our visit the highest temperature of the water where it bubbled out of the rocks, close to high-water mark, was 130° F. We therefore failed to boil some eggs in it which we had brought with us for the purpose. The water is perfectly clear and sweet,[1] and there was no trace of sulphurous vapours. Strange to say, where, though mingled with the sea, it was still too hot for the hand to be retained in it with comfort, there were a number of brilliantly-coloured fish swimming about.

Facing the landing-place is the termination of a flow of lava which extends backwards for about a mile to the base of the cone, round which it laps for perhaps $\frac{3}{4}$ of the circumference. The height or thickness of this flow of lava is about 10 feet at first, gradually rising to about 50 feet where it emerges from the base of the cone. The upper surface is deeply cleft and covered over with blocks of black cellular lava which rest upon one another in confused piles. Sometimes they are poised so insecurely one upon another that it is a matter of no little risk to attempt scrambling over them. Towards the base of the flow the rock from its slower cooling is more compact and less cellular. In places it contains white crystals of a mineral resembling leucite. In others it is a true basalt with numerous crystals of olivine.

As pointed out by Dr. Liebig, the older lava seen in the section of the ridge differs from this; it consists of a reddish matrix with crystals of felspar (probably sanidine), olivine, and augite. A somewhat similar rock occurs on Narkondam.

On our way to the central cone from the landing-place, we at first endeavoured to avoid the rough surface of the lava-flow by keeping on the slope of the gap; but after a short distance the bushes and unevenness of the ground compelled us to strike down on the lava, when we found, to our astonishment, a sort of path which must have

[1] The Andaman Committee do not appear to have realized this fact, as they spent no little time and trouble in excavating a well without finding a trace of water.

been made by the committee sent from Port Blair to report upon the supply of grass. Arrived at the foot of the cone, we commenced the ascent from the west. The loose ashes and shingle rendered it somewhat toilsome work; and those in front found it difficult to avoid loosening fragments of lava which bounded down the hill in a most unpleasant way for those who were following. Dr. Liebig appears to have ascended from the north side, where it seems to have been equally difficult. About $\frac{1}{4}$ of the way from the top there is a shoulder of rock which shows very well in the photograph. This probably marks the position of an old vent. There is a good deal of firm ground about it. The summit of the cone is truncated, and contains an oval-shaped depression, one-half of which is partly filled with débris, and the other, some 20 yards in diameter and 50 feet deep, has a circular bottom, which is filled with sand. This appears to have been the last crater formed on the island.

The two principal edges of the depression strike to north-west, south-east; they consist of ash permeated with fibrous gypsum (selenite); numerous cracks and fissures occur in this part of the hill, and the ground is hot. On turning over the surface, the sides of these cracks are found to be encrusted with sulphur, resting upon the rugosities of which small detached crystals of the same mineral were not uncommon. From the highest point on the northern edge a thin column of white vapour and sulphurous fumes is slowly poured forth. Even when standing in its midst, the fumes did not prove so irritating as might have been expected. On the southern side of the crater solid lava is seen *in sitû*, and on the west there is a peculiarly-shaped mass which forms a conspicuous object from below. Portions of the lava here have a reddish matrix and are somewhat vesicular. I also found some basalt, the outer surface of which was weathered into a white crust. It seems probable that the nucleus of the cone is solid rock to a considerable extent, the ashes seen at the surface being only superficial. By following water channels when they were to be found, and glissading over the ashes, the return to the base of the cone was effected speedily and without much difficulty.

By a small watch-aneroid supplied with a Vernier scale for feet, the height of the cone appeared to be 950 feet; but as one heavy storm of rain had passed, and clouds portended another, I am willing to believe that owing to the atmospheric disturbance the observation was not trustworthy, and that from 975 to 980 feet, given by Lieutenant Heathcote, Dr. Liebig and others, is the true elevation. The temperature on the top was 83°.

The diameter of the base of the cone is 2,170 feet according to Lieutenant Heathcote. The slopes of the cone incline, according to my observation, at angles varying between 30° and 35°. Blair, as already stated, gave it at 32° 17′, or about the mean of these two. Other observers say 40° to 45°, but a photograph of the cone, which I possess, shows that the former are correct.

Dr. Liebig has discussed the question of the amount of sulphur obtainable on the island. He seems to think the chances of finding a permanent supply very doubtful, but recommends a preliminary trial.

Considering the great expense which keeping up constant communication with the Andamans and the superintendence of convict labour would involve, I cannot see that there is any prospect of the collection and refining of the sulphur being made to pay. So far as is known, the substance occurs only at the summit of the cone, though doubtless, if the right places could be found, it does also occur lower down. But in such places, it could only be as an old deposit which, on being worked out, would not be replaced again. On the summit, deposition, so far as I could see, proceeds very slowly, certainly not with sufficient rapidity to keep labourers constantly employed.

NARKONDAM, Lat. 13° 24′ N.; Long. 94° 12′ E.

History and Previous Notices.—So little has been published regarding this island that a few lines will suffice to dispose of all that has ever been recorded regarding it.

In 1795 it was passed by Colonel Symes[1] when on his voyage to Rangoon, whence he started on his embassy to Ava. He speaks of it as "a barren rock rising abruptly out of the sea and seemingly destitute of vegetation."

Dr. McClelland, writing in 1838,[2] says:—"It is a volcanic cone raised to the height of from 700 to 800 feet." He gives a sketch showing the figure of the cone, "the upper part of which is quite naked, presenting lines such as were doubtless formed by lava currents descending from the crater to the base, which last is covered with vegetation." No soundings are to be found at the distance of half a mile from the shore. This account is reproduced by Mrs. Somerville, Dr. Daubeny, Dr. Buist, and Mr. Scrope.

Horsburgh[3] says:—"Narkondam may be seen about fourteen or fifteen leagues from the deck, and appears in the form of a cone or pyramid with its summit broken off; it is bold and safe to approach all round."

Mr. S. Kurz, in his report on the vegetation of the Andaman Islands, writes:—"Narkondam Island has an extinct volcano remarkable for the great height of its cone, being twice as high as its outer wall. Owing to the great height of the cone (perhaps 2,000 feet) in proportion to the surrounding wall, this island must have sunk very much, or the volcano must have been formed from a considerable depth in the sea." Mr. Kurz gives an outline sketch of the island as it appeared to him from a distance of twenty miles.

In a paper on the geology of the neighbourhood of Port Blair,[4] I made a few remarks on the appearance of Narkondam as seen from a few miles distance. I then accepted the height of the cone, 2,150

[1] Embassy to Ava, vol. i. 1827, p. 167.
[2] On the Difference of Level in Indian Coal-fields, J. A. S. B. vol. vii. Also in the Coal Committee's Report, and in Corbyn's Indian Review.
[3] Indian Directory, fifth edition, vol. ii. 1843, p. 55.
[4] J. A. S. B. vol. xxxix. part ii. 1870, p. 231.

feet, given on the chart, as authentic. This, it will be seen by the sequel, I do not now adopt as correct. In the *Indian Observer* for the 10th of May, 1873, a short account of the present visit will be found.

General Description of Narkondam.—Viewed from the north-west at a distance of about four or five miles, the island of Narkondam appears to consist of a tolerably regular cone which rises from an interrupted ring of irregularly piled masses. The apex is somewhat truncated, but has three distinct peaks. On the occasion in 1869 when I first saw the island, a dense mass of cloud rested on the top, as is indicated in the accompanying illustration. I was then unable to make out the character of the summit. But when subsequently seen, it was observed that there were three peaks as represented in the rough sketches published by Mr. Kurz and Dr. McClelland. The upper parts of the cone, and the sides for more than half-way down, are deeply furrowed by ravines, and what appears to be a low scrub jungle spreads uniformly over the island save upon some vertical scarped faces.

With the observers above mentioned, who did not land, the conical form alone seems to have been accepted as sufficient proof of the volcanic character of the island. Dr. McClelland, as noted above, speaks of the lined appearance being "doubtless formed by lava-currents descending from the crater to the base." These lines are, however, simply the result of erosion, and mark the position of the watercourses.

The elevation of the summit of the cone has been variously estimated at from 700 to 2,150 feet. Since, however, according to Horsburgh, the island first becomes visible from the deck of a steamer at a distance of from fourteen to fifteen leagues, it is probable that about 1,300 feet would be nearer the true altitude, and such indeed, judging by the eye, appears to be a very fair estimate.

Those who have seen Stromboli from the north-east, can scarcely fail to be struck with the extraordinary resemblance between it and Narkondam as represented in the accompanying illustration.

On the occasion of our visit in March, 1873, we landed in a small bay on the north-west side of the island. At about 100 yards distance from the beach the water became so shoal, owing to a coral reef, that we were compelled to land on a raft. We soon found that the jungle, which in the distant view appeared to consist mainly of low scrub, was really composed of large forest trees with a thick undergrowth. So dense was this, just above high-water mark, that at first it seemed probable that it would be impossible to penetrate it. Added to the natural density of the jungle, another obstacle was presented by the prostrate condition of many of the trees, which in their fall had carried down tangled masses of creepers and the lower vegetation. It soon became apparent that at no very distant period a violent hurricane or cyclone must have swept across the island. An entrance was at last found, and for three hours, cutting our way and making constant detours to avoid fallen trees, we endeavoured to force onwards to the summit, but were at length compelled to give up all hope of succeeding, and returned to the beach. Further evidence of the hurricane was there afforded by numerous fragments of a wreck which had been thrown up on the sand. Subsequently this storm was identified with one which took place on the 26th of October, 1872, and did much damage in the Cocos Islands and other parts of the Bay.

The only rock seen where we landed was a conglomerate, or boulder-bed, some 50 feet thick. The boulders consisted of a trachytic porphyry which contained sanidine, augite, and mica, in grey or pinkish matrices. We discovered no evidence whatever of recent lava or basalt occurring, though either or both may exist, as our observations were confined to one small bay. There is no historical record, so far as I am aware, of smoke ever having been observed to issue from Narkondam. It has, therefore, long been dormant, if not absolutely extinct.

Notwithstanding the luxuriance of the jungle, which included species of *Ficus*, Palms (*Caryota*), *Acacia*, *Calosanthes*, etc., no fresh water was discovered.

Much remains to be done in the exploration of this most interesting volcanic island. It is particularly desirable to ascertain whether there is really a crater at the summit, and whether there are any traces of recent lavas.

Future visitors would do well to provide themselves with some wood-cutters. They should land near the northern spur, and getting then on the steady rise, they will probably find no insuperable obstacle on their way up.

Owing to the fact of the physical geology of the Andaman and Nicobar Islands being, as yet, imperfectly known, I have not here discussed the connexion which in all probability exists between their elevation and this adjacent line of volcanic activity.

III.—Historical Geology of Cornwall.[1]

By W. A. E. Ussher, F.G.S.

To ascertain the most recent movement to which a country has been subjected, and by careful comparison with the past to discover what insensible changes are now progressing, is of the utmost importance in approaching its Quaternary History.

By a recourse to such occasional observations as have been recorded by historians or monkish chroniclers, gleaned perhaps in few cases from actual investigation, and exaggerated, no doubt, in an age delighting in the marvellous, some information may be gained; but when we consider that these notes were made rather for the gratification of the curious than with a view to ascertain their causes or to forecast their effects, and that the facts of one century may become the legends of the next, it behoves us to sift the evidence, retaining only such bare and unvarnished statements as by incidental mention and simple relation appear most

[1] The Chart to accompany this paper, of the soundings around the coast of Cornwall, not being executed in time, will appear in next month's number with the concluding historical part of this article.—Edit. Geol. Mag.

worthy of credence, especially when the accounts are corroborated by independent writers.

It has ever been the characteristic of the ignorant and uninquiring peasantry to ascribe the occurrence of great boulders of rock dissimilar to any in the neighbourhood, the fantastic shape, so frequently effected by weathering in rocks of unequal durability and such-like remarkable objects, to the agency of fabulous beings endowed with enormous strength and gigantic proportions; and so names are given to phenomena of unusual occurrence, and are retained by a less credulous posterity even when the legends which suggested them have almost entirely passed away. Many such names are to be met with in Cornwall.

Again, traditions of a more extensive coast-line, of lands now swept away, have been handed down, doubtless magnifying the extent of the ancient land, as the account passed through succeeding generations.

Our familiarity with the causes producing such phenomena as earthquakes, comets, eclipses, and the like, however seldom some of them have been experienced in a lifetime, renders the observations of the present age more accurate and less liable to exaggeration than those of preceding centuries, when anything of infrequent occurrence in the experienced operations of nature was regarded as cataclysmal, resulting from direct interposition in an unvarying state of things. The rapid advance and more general cultivation of scientific research, no longer fettered by ignorance and superstition, embraces in an ever-extending chain of cause and effect phenomena which our ancestors regarded as supernatural.

It is however curious to note how some amongst the ancients, by the acuteness of their perceptions, grasped an occasional scientific truth which has been corroborated in the present day. Thus, it is remarkable that Ovid, Pythagoras, Pliny, and Aristotle should have believed the sea to be less changeable than the land.[1] Strabo, in opposing the opinions of Eratosthenes and Xanthus as to the cause of shells being found at great elevations and distances from the sea, says: "It is not because the lands covered by the seas were originally at different altitudes that the waters have arisen or subsided or receded from some parts and inundated others. But the reason is that the same land is sometimes raised up or depressed, so that it either overflows or returns to its own place again. We must therefore ascribe the cause to the ground, either to that ground which is under the sea or to that which becomes flooded by it, but rather to that which lies beneath the sea, for this is more movable."

The historical evidence may be classified under three heads:—

Firstly, accounts of unusual disturbances of the sea by contemporary observers.

Secondly, records of disastrous inundations preserved in old chronicles.

Thirdly, traditions of the Lyonesse and probable references of the ancient geographers and historians to the Scilly Isles.

[1] Stoddart, Proc. Brist. Nat. Soc. for 1870, vol. v. p. 43.

Fourthly, the insulation of St. Michael's Mount and the identification of Ictis.

PART 1.—*Contemporary Observations.*

These have been taken exclusively from papers by Mr. Edmonds. In Edin. New Phil. Journ. he mentions an influx and reflux of the sea, varying from three to above five feet, in Mounts Bay, at five P.M., on March 23rd, 1847; the double movement taking from fifteen to twenty minutes. During the most part of the day the water, from the mouth of the Catwater to within Sutton Pool, at Plymouth, was constantly agitated by flux and reflux.

In Falmouth Harbour, and on the shores of the Scilly Isles, similar oscillations took place, whilst in St. Ives Bay nothing unusual was remarked.

At Newlyn four fluxes and refluxes of the sea occurred in an hour and a half. In the shallow water between Marazion and Penzance no agitation was perceptible. The limits of the disturbance, so far as observed, were from Mousehole on the west to Porthleven on the east, a distance of ten miles.

On October 30th of the same year, at five P.M., a rise of the sea, coming from the south-west, and reaching five feet, took place at Penzance.

Three similar fluxes and refluxes occurred at Plymouth in forty minutes.

Four whirlwinds, accompanied by shocks, passed through the parish of St. Just, on December 12th, 1846.

The same writer[1] mentions an earthquake felt over 100 miles, from the Scilly Isles through Cornwall as far as Plymouth, in July, 1757.

A disturbance of the sea took place in Mounts Bay at four hours and a quarter after the great earthquake at Lisbon in 1755, when the sea suddenly rose to the height of six feet at St. Michael's Mount, coming in from the S.E.; and to eight feet at Penzance Pier, coming in from the S.E. and S.S.E. At Newlyn Pier and Mousehole the sea coming in from the south rose and fell ten feet. Toward the decline of the commotion, the sea was found to be running at seven miles an hour in Guavas Lake.

If the observation recorded in the following extract be not magnified in transmission from the original observer, it shows the care necessary in ascribing the occurrence of some isolated pebbles and boulders above the reach of the highest spring tides to changes in the relation of sea and land: "I have been informed by two descendants of an eye-witness that at Lamorna Cove, which is on the south-east part of Mounts Bay, the sea on this occasion rushed suddenly towards the shore in vast waves with such impetuosity that large rounded blocks of granite from below low-water mark were swept along like pebbles, and many were deposited far above high-water mark. One of seven or eight tons weight was rolled to and fro several feet above high-tide level."

[1] T. R. G. S. Corn.

Whether the size of the boulders be exaggerated or not, it is evident that the disturbance described was sufficiently powerful to shift large stones from the existing beach to a point about the average height of the Cornish raised beaches above high-water mark, even allowing for an exaggeration of five feet in the height to which the large boulder was said to be moved. At Polkerris, near the Par estuary, "Raised Beach" has been engraved on the map, apparently on the strength of the occurrence of isolated quartz pebbles amid sandy debris on a small promontory some twenty feet above the adjacent beach, which is composed of exactly similar quartz pebbles. This phenomenon is much more likely to have been produced by exceptional gales, or such disturbances as have been described, than to be the relics of a raised beach, the lighter materials of which had been dissipated by spray and rain, for the raised beaches are usually too much consolidated to allow of such facile dissipation.

In February, 1759, Mr. Edmonds records a slight shock felt at Liskeard for fifteen minutes, accompanied by blood-red rays.

In March, 1761, on the day of the second earthquake at Lisbon, the sea advanced and retreated five times four hours and a quarter after ebb-tide, at five P.M., in Mounts Bay, rising six feet at Penzance and Newlyn, and four feet at St. Michael's Mount. At the Scilly Isles the agitation continued for more than two hours.

In July, 1761, fluxes and refluxes occurred in Mounts Bay, and at Falmouth, Fowey, and Plymouth.

In 1789 fluxes and refluxes of the sea were observed at Penzance and St. Michael's Mount. Earth shocks were felt on December 30th, 1832.

In 1836 a slight disturbance of the earth was felt in the parishes of Budock and Stithians.

On October 20th, 1837, a slight shock is said to have been felt in the Scilly Isles.

On February 17th, 1842, an earthquake was felt between the hours of eight and nine A.M., from Manaccan on the south to St. Cubert on the north, a distance of twenty-five miles; and from Falmouth on the east to St. Hilary on the west, a distance of eighteen miles.

On July 5th, 1843, the sea was much agitated within Porthleven Harbour. Three hundred yards from the north shore of the harbour nothing unusual was observed. At one P.M. the sea rushed in for fifty yards, reaching a height of four or five feet at Marazion. At Penzance an agitation accompanied by strange currents was observed.

The effects of the disturbances above cited are eminently transient, except in abnormal shifting of detritus to higher levels, but when we find that within the short space of a century Cornwall has felt the spent force of earthquakes propagated from distant centres of internal or eruptive motion, the probability of similar disturbances emanating from much nearer sources, and productive of considerable if not permanent effects, is at once suggested. Whilst the record of such cataclysms in early historic or mediæval times would refer to their disastrous effects, want of knowledge and observation leaving the causes unknown, the recent prehistoric geological period conceals them in an impenetrable veil.

Part 2.—*Records of Disastrous Inundations.*

I quote the following from Mr. Peacock's book (On Vast Sinkings of Land, etc.) :—

p. 116. "Dr. Barham quotes from the Saxon Chronicle, particulars of the inundation of Nov. 11th, 1099; and of another on the same authority in 1014. This year (1014) on Michaelmas Eve, Sept. 28th, came the great sea-flood which spread over this land, and ran up as far as it never did before, overwhelming many towns and an innumerable multitude of people."

p. 115. An account of a destructive inundation 13 years after the Domesday Survey, by Florence of Worcester; "On the 3rd day of the Nones of November 1099, the sea came out upon the shore, and buried towns and men very many, and oxen and sheep innumerable." From the Saxon Chronicle for that year, "On St. Martin's mass day, the 11th Nov., sprung up so much of the sea-flood, and so myckle harm did, as no man minded that it ever afore did, and there was the ilk day a new moon." "Whence," says Mr. Peacock, "the catastrophes cannot be referred to the great height of the tide, for the highest spring-tides do not occur until several tides after the new moon, and the 11th of November is several weeks after the equinox."

p. 138. Mr. Peacock accounts for Geoffery of Monmouth's omission of the mention of the inundations of 1014 and 1099, on the ground that the chroniclers very often omitted to record the actual disappearances of lands.

In p. 140 he quotes from Mr. Pengelly's paper on the Antiquity of Man in the South-West of England: "Leland (1533-1540) says, 'Ther hath been much land devourid betwixt Pensandes and Mouse-hole. Ther is an old legend . . . . . a Tounlet in this Part (now defaced and) lying under the water.'"

In p. 141 he gives a reference to Mounts Bay from Magna Britannia published anonymously in 1722 (vol. i. p. 308): "'Tis a tradition among the people here, that the ocean breaking in violently, drowned that part of the country which now is the Bay." Mr. Peacock disposes of the idea that the catastrophes of 1014 and 1099 might have been the result of similar movements to those "which occurred on the South Coast of England in 1817, 1824, and 1859, at a considerable distance of time from either equinox," on account of the unprecedented harm done by them, and the inadequacy of such high tides as those mentioned to produce commensurate effects.

Notwithstanding, I am inclined to differ from Mr. Peacock in this conclusion for the following reasons:—

Firstly. Such traditional accounts as those of Leland and the Magna Britannia, and the statement of Vice-Admiral Thevenard in

Mem. relatifs à la Marine (A.D. 1800), "La submersion du terrain . . . et de la pointe ouest de l'Angleterre. IX." (commencement of ninth century), quoted by Mr. Peacock in p. 88 of his book, must be laid out of the question.

Secondly. All statements made by writers who lived long after the occurrences they describe must be accepted with reservation, as they may have been derived from the contemporary record of the occurrence, and cannot, therefore, be said to furnish additional evidence. Thus with Florence of Worcester, who wrote in the thirteenth century.

Thirdly. Taking the Saxon Chronicle as the only direct contemporary account of the inundations of the eleventh century, one would like to know whether the descriptions there given were penned by an eye-witness of the catastrophe, or inserted from rumours which would doubtless have magnified the disaster ere they reached the chronicler.

Fourthly. Admitting Mr. Peacock's reason for the omission of remarkable events here and there by the chroniclers generally, I cannot see their particular application to Geoffery of Monmouth, who flourished in the twelfth century, and would therefore have less excuse for omitting to mention events, which had been witnessed by the generations immediately preceding him, than Florence of Worcester, who lived more than three centuries after they had occurred. For these reasons I am disinclined to believe in sudden elevations or depressions of land, and to consider that, owing to some such disturbances as I have quoted from Mr. Edmonds, though perhaps of greater magnitude, lives may have been lost and lands devastated by the influx of waves propagated by earthquake shocks, and by seasons of unprecedented flood. That the effects produced would be partial or transient, whilst the story of the disaster for which men could assign no cause would be magnified as it passed from the eye-witnesses of the catastrophe to their descendants, and finally, with many interpolations and distortions, live as a local tradition with perhaps very little of its original significance remaining.

PART 3.—*Traditions of the Lyonesse, &c.*

The following information is chiefly extracted from Mr. Peacock's book :—

"It is said that in Camden's time the inhabitants of Cornwall were of opinion that the Land's End did once extend further to the west, which the seamen positively conclude from the rubbish they draw up, and that the land there drowned by the incursions of the sea was called Lionesse. That a place within the Seven Stones is called by the Cornish people Trevga (*i.e.* a dwelling), and that windows and other such stuff have been brought up from the bottom there with fish-hooks, for it is the best place for fishing. That at the time of inundation supposed Trevelyan swam from thence (at least 15 nautical miles to the nearest part of the mainland) and in memory thereof bears Gules, an horse Argent issuing out of the sea proper." (*Vide* Note A.)

"If the Lyonesse country really existed in Ptolemy's time (A.D. 117 to 161), it cannot have extended as far westwards as is shown on the map in the Churchman's Magazine (for July, 1863, p. 39), from Land's End and Lizard Point to and comprising the Scilly Isles. Because Strabo, who flourished at least a century before Ptolemy, quoting Posidonius, who was still older, mentions those islands as then existing under the name of Cassiterides (book iii. cap. ii. § 9), and that they were ten in number (*Ibid.* cap. v. § 11)."

"Dr. Paris, in his 'Guide to Mounts Bay and the Land's End,' p. 91, mentions Camden's tradition of the Lyonesse (the Silurian Lyonois), said to have contained 140 parish churches, all of which were swept away by the ocean." He says further that the Scilly Isles are now 140 in number, though only six are inhabited.

Camden (Britannia, edit. 1722) says, "The Scilly Isles are called by Antoninus, Sigdeles; by Sulpitius Severus (died A.D. 420), Sillinæ; by Solinus, Silures; by Dionysius Alexandrinus, Hesperides; by Festus Avienus (latter part of fourth century), Ostrymnides; by several Greek writers, including Diodorus, and by Pliny the Elder, Cassiterides."[1]

Dr. Borlase,[2] in a letter to the Rev. J. Birch on the Scilly Isles, says that the present inhabitants are new comers, having no connexion with the old race, as all the antiquities found in the islands belong to the rudest Druidic times.

In isles now uninhabited and not used for pasturage, rude stone pillars, erect circles of stone, kistvaens, innumerable rock basins, and tolmens,[3] are found, whilst the small islands, tenements, and creeks, are called by British names.

Within the three years previous to 1753, he states that the advance of the sea in the Scilly Isles has been very considerable; this advance being, in his opinion, due to subsidence for the following reasons: Strabo's opinion as to their number (*vide suprà*) and as to one only being desert and uninhabited; the fact that the Isle of Scilly, which gives its name to the group, is now a high barren rock, a furlong across, with cliffs to which only sea-birds can obtain access.

The flats which stretch from one island to another are plain evidences of a former union between many now distinct islands. The flats between the islands of Trescan, Brehar, and Sampson, are left quite dry at a spring-tide low-water, when walls and ruins have frequently been seen through the shifting sands, covered by 10 to 20 feet of water at high tide. As these foundations were probably at one time six feet at least above high-water mark, the advance of the sea by denuding action alone would be insufficient to account for their present position, "ten feet below high-water." Whence he considers that "a subsidence amounting to 16 feet at least has taken

[1] Peacock, p. 109.

[2] Phil. Trans. for 1753, vol. 48, p. 326.

[3] Tolmens.—Oval or spheroidal rocks, when resting on two others, with a cavity between, are called by Dr. Borlase tolmens (stones with holes), and are supposed by him to have been rock deities (Carne on the Scilly Isles).—T.R G.S. Corn. vol. vii. p. 144.

place, which caused the desertion of the islands by their terrified aboriginal inhabitants. These original inhabitants carried on a trade in tin with the Phœnicians, Greeks, and Romans" (for this opinion he cites Diodorus Siculus, lib. v. cap. ii. and Strabo, Geog. lib. iii.). "Whilst only one inconsiderable vein of tin occurs in Tresco Island, and that betrays no sign of ancient working, nor are any old workings now visible sufficient to have maintained a trade in tin." He says further, "But though there are no evidences to be depended on of any ancient connexion of the Land's End and Scilly, yet that the cause of that inundation which destroyed much of these islands might reach also to the Cornish shores, is extremely probable, there being several evidences of a like subsidence of the lands in Mounts Bay."

Dr. Borlase, in his Natural History of Cornwall,[1] says, "The supply of tin from Gades and Spain being too small to supply the vast trade as far as India, they must have got it to the east of the Damnonii."

The Chaldeans and Arabians call tin by a name similar to the Greek *κασσιτερον*. The Scilly Isles were called Cassiterides long before the Greeks knew of their position, for Herodotus (B.C. 400) says, *Ουτε νησας οἶδα Κασσιτεριδας εκσας εκ των ὁ κασσίτερος ἡμιν φοιτᾳ.*

Solinus calls them Insulæ Silurum or Insula Silura, perhaps in mistake for islands off the Welsh coast.

Tacitus[2] says the Silures were opposite to Spain, which would point to the Scilly Isles. It is probable that the Phœnicians regarded West Cornwall as an island, and one of the Cassiterides, as the Scilly Isles alone would have been totally insufficient to afford the supply.

"Ortelius,[3] therefore, not without reason, makes the Cassiterides to include, not only the Scilly Isles, but also Devonshire and Cornwall."

"Tin was also anciently found in Lusitania and Gallicia."[4]

Mr. H. Boase[5] quotes Carew[6] as follows:—"The encroaching sea hath ravined from it the whole country of Lionnesse, together with divers other parcels of no little circuit, and that such a Lionnesse there was, these proofs are yet remaining. The space between the Land's End and the Isles of Scilly, being about 30 miles, to this day retaineth that name, in Cornish, Lethowsow, and carrieth an equal depth of 40 or 60 fathoms, save that about midway there lieth a rock which at low water discovereth its head. They term it the Gulf, suiting thereby the other name of Scilla. Fishermen also casting their hooks thereabouts, have drawn up pieces of doors and windows." After touching on Dr. Borlase's views, Mr. Boase[7] proceeds to say, "The arguments adduced by our old historians in proof of the tradition, refute themselves. In the first place, the sea is no shallower between the Land's End and Scilly, than at equal distances from land, on other parts of the coast; and the midway

[1] p. 29. [2] Ib. p. 30. [3] 1527–1593. [4] Ib. p. 29.
[5] T.R.G.S. Corn. vol. ii. pp. 130, 131. [6] Carew, p. 3. [7] Op. cit. p. 132.

gulf or Wolf-rock, happens not to be in that channel at all, but considerably to the south of it; and as to the stories of fishing up pieces of doors and windows, and seeing tops of buildings, etc., had all the buildings, doors, and windows of Cornwall, been placed there, the first tempest would have swept them all away, as pebbles before a torrent. The truth is, that no such relics were ever discovered, or could have remained for discovery, in that boisterous channel of the Atlantic Ocean."

With the above opinion I entirely agree, for the very mention of windows dredged up is sufficient to refute any testimony of an historical connexion of the Land's End with the Scilly Isles based upon it. Except as fragments of wreck, it is impossible to conceive the occurrence of such material in the places specified.

(Peacock p. 140.) The tradition of the loss of area on the West of Land's End is thus mentioned by Harrison (An Historical Description of the Island of Britaine, by W. Harrison, prefixed to Hollingshed's Chronicles, 1586, vol. i. lib. iii. ch. 10, p. 397): "A remarkable corroboration of Ptolemy's positions of the promontories Belerium and Ocrinum,"[1] as Mr. Peacock thinks, "It doth apeere yet by good record, that whereas now there is a great distance betweene the Syllan Isles and point of the Land's End, there was of late years, to speke of scarslie a brooke or drain of one fadam water betweene them, if so much, as these evidences appeereth and are yet to be seene in the hands of the lord and chiefe owner of those Isles."

Dr. Paris and Mr. Carne[2] considered that St. Just in the Land's End district might have been meant by the word Cassiterides, owing to the traces of tin in the Scilly Isles being insufficient to justify that appellation. Mr. Carne,[3] speaking of Piper's Hole, in Tresco Island, as a supposed adit of the ancient tin works, objected that as it is above high-water, it is just such a site as would be selected now. He further considers that, if any mines had ever been productive in the Scilly Isles, some traces of diluvial tin ore would even now be found from time to time in the low-lying tracts in St. Mary's, and on the south-eastern side of Tresco.

Mr. Peacock[4] quotes Diodorus Siculus as follows:—"Far beyond Lusitania (Portugal) very much tin is dug out of the islands in the ocean nearest to Iberia (Spain), which from the tin are named Cassiterides."

D. P. Alexandrinus, who flourished in the time of Augustus, says in his Geography, line 599, etc.: "But beyond the Sacred Promontory (Cape St. Vincent), which they affirm is the extremity of Europe, in the islands Hesperides, where the source of tin is, the rich children of the illustrious Iberi dwell." Mr. Peacock thinks that the Scilly Isles are here alluded to under the name Hesperides.

Strabo has told us that Publius Crassus saw that the metals were

[1] Peacock, p. 109.

[2] Mr. Carne (T.R.G.S. Corn. vol. ii. p. 354) says, "It is exceedingly probable that the western extremity of England, of which St. Just forms a prominent part, constituted the principal portion of what was formerly known under the name of the Cassiterides."

[3] T.R.G.S. Corn. vol. vii. p. 153.

[4] Peacock, p. 106.

dug out at a little depth in the Cassiterides (book ii. cap. v. § 15); this was about 57 B.C.

Strabo further describes the Cassiterides as "islands in the high seas just under the same latitude as Britain, northward and opposite to the Artabri."[1]

(To be continued in our next Number.)

NOTICES OF MEMOIRS.

On the Geology of the West Balkan.[2] By Fr. Toula. (Proceed. Imper. Acad. Vienna, March 14, 1878.)

THE southern margin of the Berkowiza-Balkan is composed of Tithonian coral-limestones. Beneath these lie Middle-Liassic strata, with *Belemnites paxillosus*, *Spiriferina verrucosa*, *Rhynchonella* (near *curviceps*), and *Gryphæa* (near *cymbium*). Beneath these are dark-tinted limestones with Crinoids, small Gasteropods, *Lima radiata*, and *Retzia trigonella* (Recoaro Limestones), resting on red sandstones of the Werfen Schists, which in their turn rest on argillaceous schists of the Carboniferous (Culm) Formation. The Lower Triassic Limestones stretch out wide above Pecenoberols, and upwards to the summit of the defile, where they are seen to rest on intensely yellow sandstones containing *Myophoria costata*. Near Ginci-Han Liassic beds appear again. Their organic remains are—*Belemnites paxillosus*, Schlth., *Pleurotomaria* (near *expansa*, Sow.), *Rhynchonella acuta*, Sow., *Spiriferina rostrata*, Schlth., *Lyonsia unioides*, Gldf., *Pecten liasinus*, Nyst, *Pect. sublævis*, Phill., *Plicatula* (near *spinosa*, Sow.), *Gryphæa* (near *fasciata*, Tietze). The steep northern slope is formed of granite, intersected by many veins of andesite. Farther off, crystalline schists extend to beyond Berkovac. On the whole, the Berkoviza-Balkan is an independent portion of the Balkan chain. Cretaceous deposits are wanting throughout the section, except that perhaps the coral-limestones on the southern side may possibly be Lower Cretaceous, if not Tithonian.

The crystalline schists past the line Berkovaz-Vraza are succeeded by Palæozoic argillaceous schists and conglomerates, overlain by red sandstones and light-coloured limestones. Mighty masses of these limestones, locally abounding with organic remains (*Thamnastræa*, *Actinaræa*, *Reptomulticava*, *Chætetes Coquandi*, Mich., *Lithodomus*, *Caprotina Lonsdalei*, d'Orb.), rise above the Lower Triassic deposits. Near Vraza, sandy limestones and marls, characterized by the presence of *Orbitolinæ*, appear on the northern base of the Caprotina-limestones. Several of their beds abound with fossils, as,—*Ostrea Vrazaënsis*, sp. nova, *Rhynchonella* (near *lata*, d'Orb.), *Terebratula*, *Waldheimia*, *Cerithium Forbesianum*, *Turbo*, *Astarte numismalis*, *Cyrena* (?) *lentiformis*, Rœm., *Cardium* (near *Ibbetsoni*), *Pecten*, *Areopagia gracilis*, sp. nova, *Terebratula*, and *Rhynchonella lata*.

[1] Peacock, p. 107.

[2] Notes on the Geology of other parts of the Balkan, by M. Toula, are given in the Geol. Mag. Dec. II. Vol. IV. p. 518.

The organic remains in the Inoceramus-limestone between Vraza and Ljutiobrod are,—*Galerites* (*vulgaris ?*), *Ananchytes ovatus*, *Cardiaster pilula*, *C. ananchytis*, *Inoceramus* (near *Crippsi* and *Cuvieri*), *Terebratula* (near *Hebertina*), *Trochus*, *Ammonites* (*Harpoceras*), *Hamites*. Beneath these strata lie sandy limestones, abounding with *Orbitolinæ*, resting on Bryozoan limestones. These contain *Reptomulticava micropora*, *Ceriocava subnodosa*, *Multicrescis Michelini*, etc., together with spines of *Cidarites*, *Nucleolites* (near *Olfersi*), *Terebratula*, *Ostrea* (near *Boussingaulti*), *Lima Tornbeckiana*, and *Serpula filiciformis*. Caprotina-limestones appear farther southward. The whole series reminds one of the three subdivisions of the "Schratten Limestones" in the Northern Alps, resting to the south on red sandstones and conglomerates. Lower Triassic red sandstones, resting on quartzite schists, and overlain by Lower Triassic limestones, are amply developed between Cerepis and Obletnja. Melaphyres and diorite are widespread. Granite appears at two places. At one spot on the banks of the River Isker the Triassic limestones contain *Natica*, *Pecten Alberti*, *Modiola triquetra*, *Gervillia socialis*, *G. mytiloides*, *Leda*, *Myophoria costata*, *M. lævigata*, *M. elegans*, *Myoconcha gastrochæna*, *Anoplophora* (near *musculoides*), etc.

Argillaceous schists of the Carboniferous formation (Culm), cropping out from beneath red sandstones, prevail in one part of the Isker Valley, striking N.—S. Some intercalated sandstones yield vegetable remains, as *Archæocalamites radiatus*, *Cardiopteris polymorpha*, *Neuropteris antecedens*, *Stigmaria inæqualis*, and *Lepidodendron Veltheimianum*. The Culm schists continue as far as Ronca, where red conglomerates and sandstones appear again, forming the narrow defile through which the River Isker enters the gorges of the Balkan.

COUNT M.

REVIEWS.

I.—MANUAL OF THE GEOLOGY OF IRELAND. By G. HENRY KINAHAN. 8vo., pp. 444, Map, 8 Plates, and 26 Woodcuts. (London, Kegan Paul & Co., 1878.)

UPWARDS of twelve years ago Lyell observed how increasingly difficult he felt it to keep up with the progress of geology. And every student of the science must continually be impressed with this difficulty. The grand work of our American brethren is in itself an immense study, and so important is the light it has thrown on every branch of geology, that it possesses a world-wide interest. But while the GEOLOGICAL MAGAZINE and the Geological Record announce to us periodically what has been done, and what is being done, the number of isolated works is too great, and access to them often too difficult, for those who wish to glean the sum and substance yielded by minute observation.

And in the British Islands, as has been often remarked, the increase in our knowledge becomes every year more and more a matter of local detail, supplementing and illustrating the work and conclusions of those who sketched out the main features in their geology. Hence the work of summarizing the labours of all becomes a desideratum, and it is somewhat surprising that until the past year no epitome of the Geology of Ireland had appeared.

Two works have however now been given to us; but while both aim at illustrating the geology of the sister isle, in no sense can they be considered as rivals—the one supplements the other.

Professor Hull's work, to which attention was lately directed, gives in outline the chief features in the Geology of Ireland, and dwells more especially upon the physical history of the rocks, and the sculpturing of the scenery. Mr. Kinahan's work, now before us, aims to give a more detailed account of the strata, and of the facts to be observed in the field, thus acting as a guide to the geologist in his explorations.

As the general features of the Geology of Ireland were pointed out at some length in the notice of Prof. Hull's book (see Geol. Mag. March and April, 1878), and as Dr. Evans again alluded to them in his Address to the Geological Section of the British Association at the Dublin Meeting (see Geol. Mag. Sept. 1878), it will be unnecessary to go over the same ground again.

After a brief and concise introduction, Mr. Kinahan proceeds at once to the description of the stratified rocks, which take up the first section of the book.

The oldest Palæozoic rocks are grouped as Cambrian (Sedgwick), Cambro-Silurian (Phillips), and Silurian (Jukes). In the case of the term Silurian, although, as we think rightly, the author does not include all the beds embraced under that denomination by Murchison, yet we think the name of the author of the Silurian system should certainly have been bracketed to it.

The separate subdivisions are described under local geographical names, and their probable English equivalents are given in a table.

Much interest attaches to the Dingle beds or Glengariff grits, which overlie true Silurian (Ludlow) rocks, with apparent conformity, in the Dingle promontory.

In this promontory the beds are described as consisting "of green and purple grits and slates which pass up into beds of coarse thick sandstones and grits of greenish and reddish tints, like those in the neighbourhood of Glengariff, County Cork, and interstratified similarly with purple slates." No fossils proper to the group have been found in them. But in the Iveragh and Dunkerron promontory "there is a conformable sequence extending upwards into the Carboniferous slate and limestone." In the Glengariff grits, south and south-east of Dingle Bay, obscure tracks and plant-like markings have been met with in the beds.

Professor Hull remarks that the Dingle Beds "are overlaid in a highly discordant manner by the red sandstones and conglomerates of the Old Red Sandstone formation." Nevertheless, as he adds, "they have been placed by the Government Surveyors in a kind of neutral territory, and are provisionally unattached to either of the formations with which they are in contact."

Mr. Kinahan places the Dingle Beds, as does Professor Hull, rather with the Silurian; but his section (p. 54) to show the unconformable overlie of the Lower Carboniferous sandstones and shales (=Old Red Sandstone, etc.) is not quite clear, for it is suggestive of a fault between what he there marks as "Old Red Sandstone," and the Dingle or Glengariff grits. Jukes, it should be observed, thought it expedient to join the Dingle or Glengariff grits to the overlying rocks rather than to the Silurians.

As even Professor Hull links these beds doubtfully with the Silurians, one would have been glad to have been furnished with sections showing more clearly the actual facts, inasmuch as the question is of much importance in its bearing upon the relations of the Silurian and Old Red Sandstone, and of the Devonian and Carboniferous strata.

It may be well to bear in mind that in the south-west of England and South Wales, De la Beche found great difficulty in drawing a hard line between the Silurian and Old Red Sandstone, while in Gloucestershire and Somersetshire the Old Red Sandstone passes up most gradually into the Lower Carboniferous Rocks.

Hence, when Mr. Kinahan includes the Old Red Sandstone of Ireland in the Carboniferous formation, "because in no place in Ireland has it a defined upper boundary, one group graduating into the other," we feel that, while he may be right in theory, the practice will be found a very inconvenient one, and inconsistent with the classification elsewhere adopted. It is only right to add, what he tells us further on, that "only in Munster and in the hills between Lough Erne and Pomeroy, counties of Fermanagh and Tyrone, is the Old Red Sandstone at the absolute base of the Carboniferous formation; as in all other places the rocks so called and described are on different geological horizons, ranging up to the base of the Coal-measures." And he shows that this is due to the repetition of sandstones or "shore-beds" throughout the Lower Carboniferous series. The diagram fig. 5, illustrating the changes from the shore-beds into the Carboniferous Limestone, might, we think, have been drawn a little more naturally, without interfering with its object.

The following table shows the general grouping of the Carboniferous rocks adopted by Mr. Kinahan:—

CARBONIFEROUS	Coal-measures.	
	Carboniferous Slate, including the Coomhoola Grits, and the Carboniferous Limestone.	
	Yellow Sandstone	Lower Carboniferous Sandstone and Shales.
	Old Red Sandstone	

The interchange of sedimentary conditions exhibited in this series, forms a very interesting study, and one with which all students of the Devonian rocks must make themselves acquainted, in picturing the physical history of those deposits.

Detailed accounts of the Coal-measures are given, with records of the organic remains, and of the Coal-seams in the several Coal-fields.

The Permian rocks are bracketed with the Mesozoic division, and Mr. Kinahan observes that in Ireland all the undoubted Permian rocks seem to be intimately connected with the associated Triassic rocks, while the Rhætic beds above seem to graduate from them into the Jurassic rocks, as they do in England.

The Lower Lias is next described, and the alteration of the Portrush Lias into Hornstone is attributed to the intrusion of the granitic rocks of the district, and the metamorphic influence of steam or heated water.

Accounts of the Greensand, Chalk, and Miocene strata are given, including the Miocene Iron-ore measures.

A description of the Pliocene Clays of Lough Neagh completes the first section of the book.

Section 2 is devoted to the Metamorphic and Eruptive rocks, and here we are introduced to some new terms. Thus Metamorphic action is described as in some cases *Regional*, extending over large areas, and due to "the influence of intensely heated water or steam, which, as it were, stewed them [the rocks], from which the action may be called METAPEPSIS." In other cases the Metamorphism may be *Local*, adjoining intruded masses of rock, etc., which give the strata a baked appearance ; hence this change is termed PAROPTESIS. A third kind of Metamorphism, due to the introduction and action of chemical substances from without, is called METHYLOSIS. It may be questioned whether the introduction of these words is a benefit to the student, who would no doubt be satisfied with the terms Regional and Local Metamorphism. But Mr. Kinahan is not altogether unknown for the introduction of peculiar terms, and in his Introduction speaks of the Eruptive rocks as Granitic or Catogene, that is rocks formed beneath the surface of the earth at greater or less depths ; and as Anogene, or rocks formed on or close to the surface of the earth.

Section 3 is devoted to the Superficial Accumulations, Glacial and Aqueous Drifts, and Meteoric Drift (Æolian or wind-formed drift) ; the subjects of Glaciation, Erratic Blocks, Raised Beaches, and Submerged Land and Forests, Peat-Bogs and Pre-historic Remains, Soils, etc.

Section 4 contains an account of the Physical Features, Escarpments, Cliffs, Hills, and Cooms, of the Valleys and Subterranean Rivers, the Bays, Lagoons, Lakes, and Islands.

Speaking of the Valleys, Mr. Kinahan says, "It is a popular belief that Rivers and Streams have excavated the valleys in which they flow. This may be the case in reference to some valleys no doubt, but in Ireland in general, the rivers are due to the valleys, not the valleys to the rivers ; the valleys occupying dykes of fault-rock or lines of breaks or other skrinkage fissures in the strata or accumulations in which they are situated." This statement, which forms the opening paragraph to Chapter XIX., is well calculated to evoke criticism. We are quite prepared to acknowledge that Faults, Fissures, and Joints have had great influence in originating or modifying the courses of rivers, but clearly the rivers in most cases have carved out the valleys. Indeed, Mr. Kinahan himself speaks of the Ovoca and its tributaries as occupying deep narrow valleys excavated along lines of faults.

Section 5 embraces the subjects of Economic importance, Mines and Minerals, with a list of Mineral Localities, Stones, Quarries, and Mineral Manures, and Water Supply. An Appendix gives a glossary of Geological and Celtic terms.

In conclusion we can only speak in the highest terms of the appearance of the book, which is exceedingly well printed and bound. The geological illustrations are diagrammatic and pictorial, but the figures of fossils by Mr. W. H. Baily scarcely do justice to the author of "Figures of Characteristic British Fossils." The map on a scale of 27 miles to one inch is very nicely executed, and shows at a glance the chief features of the Geology of Ireland. We can cordially recommend Mr. Kinahan's book to every student of British geology, and especially to those who desire to go into the field and observe for themselves.

Geological Map of Heidelberg.

II.—Geognostische Karte der Umgegend von Heidelberg. Bearbeitet von Dr. E. W. Benecke und Dr. E. Cohen. Mit Unterstützung des Grossh. Badischen Handelsministeriums. (Blatt I., Heidelberg.) (Strassburg, 1877: Karl J. Trübner; London, Trübner & Co.)

FOUR years since [1] we had the pleasure of directing the attention of our readers to the publication of a sheet (Sinsheim) of a geological map of a portion of the Grand-Duchy of Baden, in which the authors proposed to have incorporated the results of a lengthened study of the area immediately surrounding Heidelberg. The sheet then issued, the southern half of the projected map, showed the district lying south of the Neckar Valley, and east of the railway running south from Heidelberg. The present sheet, which, though the last issued, is numbered "Blatt I.," embraces the area lying east of the University town as far up the Neckar Valley as Hirschhorn, with a smaller map of Eberbach, and its curious outcrops of nephelinite, and extending as far north along the Bergstrasse as Weinheim. Over this area granite, often containing hornblende, and deposits of barytes distinguish it from the region lying further south, where Trias beds cover a great portion of the surface. The subdivisions of the sedimentary and the varieties of the igneous rocks are carefully indicated in colour, and the contours are given in great detail. The map is a production of which the authors have good cause to feel proud, and as a specimen of colour-printing it is everything that could be desired. The scale of the map is 1 : 50000.

It is to be regretted that the explanatory text, which the authors stated, at the time they issued the first sheet, should accompany the publication of the present one, has not yet been provided. It would prove of great benefit to those geologists who may desire to use the map in the field, and should not have been withheld.

[1] Geol. Mag. 1874, Decade II., Vol. I. p. 326.

REPORTS AND PROCEEDINGS.

The Geological Society of London.—I.—November 6, 1878.—Henry Clifton Sorby, Esq., F.R.S., President, in the Chair.

The following communications were read :—

1. "On the Range of the Mammoth in Space and Time." By Prof. W. Boyd Dawkins, M.A., F.R.S., F.G.S.

The author expressed his opinion that the result of the evidence collected since the death of Dr. Falconer has been to establish the view of that palæontologist as to the Mammoth having appeared in Britain before the Glacial epoch. The evidence as to the occurrence of the Mammoth in the south of England was first examined. The remains found beneath the bed of erratics near Pagham belonged, not to *Elephas primigenius*, but to *E. antiquus*. But in 1858 remains belonging to the former were found by Prof. Prestwich under Boulder-clay in Hertfordshire. In Scotland remains of *E. primigenius* have been found under Boulder-clay; but whether under the oldest Boulder-clay is uncertain. In 1878 a portion of a molar was brought up from a depth of 65 feet near Northwich. It was in a sand beneath Boulder-clay, which the author considered to be undoubtedly the older Boulder-clay. The author now assents to Dr. Falconer's opinion (which he formerly doubted) that *E. primigenius* was a member of the Cromer Forest-bed fauna. It is also clear that it was living in the southern and central parts of England in Postglacial times. It has not been found north of Yorkshire on the east, and Holyhead on the west, probably because Scotland and North-west England were long occupied by glaciers. Its remains have been found on the continent as far south as Naples and as far north as Hamburgh, but not in Scandinavia. Its remains, as is well known, abound in Siberia, and it ranged over North America from Eschscholtz Bay to the Isthmus of Darien, *E. columbi*, *E. americanus*, and *E. Jacksoni* being only varieties. The author then discussed the relations of *E. primigenius* to *E. columbi*, *E. armeniacus*, and *E. Indicus*, and came to the conclusion that it is the ancestor of the last.

2. "The Mammoth in Siberia." By H. H. Howorth, Esq., F.S.A. Communicated by J. Evans, Esq., LL.D., F.R.S., V.P.G.S.

The author gave reasons for considering that the "griffon's claw" sent by Harun-al-Rashed to Charlemagne was the horn of a fossil Rhinoceros, so that the extinct mammals coeval with the Mammoth were known in Europe at an early date. They were probably known even in the days of Heredotus. Other evidence, such as the Christy Collection, shows that the Siberian deposits were known at a very early time. There is evidence, too, to show that fossil ivory was known to the Chinese, who asserted that the animals were still living underground. The author described several cases of the discovery of well-preserved bodies of Mammoths in historic times. They have occurred in widely separated places, from the eastern watershed of the Obi to the peninsula of the Tschuksi. Bones also have been found over the whole length of Siberia, the Brai Islands, and the islands of New Siberia.

The author further discussed the theories which account for their presence:—1. That the animals lived much further south, and were carried down by rivers to where they now lie. 2. That they lived on the spot. As there are physical difficulties in the way of the transport theory, as the Mammoth was covered with dense hair, and fed on plants growing on the spot, and as the remains are not confined to the vicinity of rivers, it is probable that the second view is the correct one.

There are, however, some points connected with it requiring further consideration. It being proved that the Mammoth only required a temperate climate, it must not be hastily assumed that it could endure that of Siberia. Where the Mammoths are now found the ground at two or three feet below the surface is permanently frozen all the year round, vegetation does not appear till June, the summer is very short, the winter proportionately long, vegetation poor and stanted, the temperature in January is as low as —65° F., and no tree will now grow in the greater part of North Siberia. How then could *Elephas primigenius* and *Rhinoceros tichorhinus* obtain food on such ground? The only alternative seems to be, either to suppose a great migration N. and S., or a change of climate. The author is of opinion that in Siberia such a migration is not possible. It seems therefore more probable that the climate of Siberia has become more severe. The plants found in the fissures of the Rhinoceros-teeth are those now living in South Siberia. The plant-remains associated with the Mammoth (not floated from a distance, but of the locality) show the same thing, larch, birch, and other trees of good size being found. Freshwater and land shells are also found, not now living. Hence it seems reasonable to conclude that the climate has become more severe, and that of the north in the days of the Mammoth resembled that of the south at the present time. The author then considered the cause of the Mammoth's extinction. This he held to have been sudden. The remains must have been preserved soon after death. He therefore maintains that they were destroyed by a flood due to some sudden convulsion which also changed the climate.

3. "On the Association of Dwarf Crocodiles (*Nannosuchus* and *Theriosuchus pusillus*, e. g.) with the diminutive Mammals of the Purbeck Series." By Prof. R. Owen, C.B., F.R.S., F.G.S.

The author noticed an objection which had been raised to his view of the origin of the differences between the Mesozoic and Neozoic Crocodiles by the adaptation of the latter to the destruction by drowning of large mammalia (Q. J. G. S. xxxiv. p. 422), namely that mammals were coexistent with the Mesozoic forms, and remarked that from their small size they would hardly constitute a suitable prey for the Crocodiles to which he then specially referred, but would be more likely to perform the same part as the Ichneumons of the present day, which check the increase of Crocodiles by destroying their eggs and newly hatched young. He stated, however, that in some slabs of "feather-bed" marl which accompanied the Becklesian Purbeck Collection to the British Museum, the remains of small Crocodiles were detected in considerable abundance; and he gave a description of these, and especially of one which he named *Theriosuchus pusillus.* This reptile, which is estimated to have been about 18 inches long, had scutes presenting the "peg and groove" character of those of *Goniopholis,* with which genus it further agreed by having the antorbital part of the skull of the broad-faced Alligator type. In the dentition it resembled the Triassic Theriodonts more than any other Crocodiles. The vertebræ are amphiplatyan. In conclusion, the author indicated the conditions which have to be fulfilled in the case of recent Crocodiles to enable them to drown a large mammal without inconvenience to themselves, and showed that these conditions were realized also in the Neozoic forms, whilst there was no reason to suppose that any Mesozoic Crocodiles possessed the adaptations in question.

II.—Nov. 20, 1878.—R. Etheridge, Esq., F.R.S., Vice-President, in the Chair.—The following communications were read:—

1. "On the Upper-Greensand Coral Fauna of Haldon, Devonshire." By Prof. P. Martin Duncan, M.B. Lond., F.R.S., F.G.S., etc.

The author in this paper stated that since the publication of his supplement to the British Fossil Corals, published by the Palæontographical Society, several new corals have been obtained at Haldon by Mr. Vicary, of Exeter. Twelve additional species were noticed, of which ten were new. This brings the total number of species in the Haldon Greensand up to twenty-one. The new species are thus distributed: —*Aporosa*: Oculinidæ (1), Astræidæ (3), Fungidæ (5); *Perforata*: Turbinariæ (2); *Tabulata* (1). The paper concluded with remarks on the genera and species represented, from which it appeared that the Coral fauna of Haldon is the northern expression of that of the French and Central European deposits, which are the equivalents of the British Upper Greensand. The Haldon deposit was formed in shallow water, and the corals grew upon the rolled débris of the age.

2. "Notes on *Pleurodon affinis*, sp. ined., Agassiz, and description of three spines of Cestracionts from the Lower Coal-measures." By J. W. Davis, Esq., F.G.S.

The author described some fossil remains of fish obtained from the bone-bed immediately above the "Better-bed Coal" referred to by him in a former paper (see Q. J. G. S. vol. xxxii. p. 332). The fossils described included Ichthyodorulites belonging to 4 species, namely:—*Pleurodus affinis,* a species named, but not described or figured, by Agassiz; *Hoplonchus elegans*, gen. et sp. nov.; *Ctenacanthus æquistriatus*, sp. nov.; and *Phricacanthus biserialis*, gen. et sp. nov. Teeth, believed to be those of *Pleurodus affinis,* were also described.

Specimens anything like perfect are very rare. He suggested that the coal, after having been formed on land, probably became the bed of a lake or an open shore-line. He remarked that this thin bed extended uniformly over a very considerable area. In reply to Prof. Morris, he stated that the Geological Survey had adopted a different line of division between the Middle and Lower Coal-measures from that formerly suggested by Prof. Phillips. He pointed out that marine and freshwater species of fish appeared to co-exist in the Carboniferous beds, and compared this with the analogous case of the Lake of Nicaragua, as described by the late Mr. Belt. Freshwater forms of sharks are not unknown in the Ganges and other rivers.

3. "On the Distribution of Boulders by other Agencies than that of Icebergs." By C. E. Austin, Esq.,C.E., F.G.S. (a theoretical paper).

CORRESPONDENCE.

ADDITIONAL NOTES ON THE NORTH DEVON SECTION.

Sir,—Permit me to make one or two additional notes to those contained in the Geological Magazine for December on the North Devon Section.[1] Since they were written, the volume of Proceedings of the British Association for 1877 has come to hand, containing a short paper by Prof. G. Dewalque, "On the Devonian System in England and in Belgium,"[2] which is of much interest at the present time, as coming from so high an authority on the Devonian question as regards Belgium and its borders. M. Dewalque comes to the conclusion (1) that the North Devon series is perfectly continuous from Barnstaple to Linton; and (2) that "nowhere is there a reappearance of such identical rocks as to prove, by repetition of the series, the existence of a fault," so that Mr. Etheridge's views and those of observers who agree with him receive an important confirmation on this point.

M. Dewalque also concurs in the view that the Pilton and Barnstaple Beds are of Lower Carboniferous age, in fact representatives of the Carboniferous Limestone, in which case the underlying "Baggy and Marwood slates," with *Cucullæa,* must be the representatives of the Lower Carboniferous slate and Coomhola Grit of the South of Ireland. I have just discovered that this view was for the first time advocated by the Rev. Professor Haughton, F.R.S., in a valuable paper on "The Evidence afforded by Fossil Plants as to the Boundary-Line between the Devonian and Carboniferous Rocks," published in 1856.[3] The concurrence, therefore, of evidence and opinion on the age of these beds may, I think, be considered to have completely established the Carboniferous age of those beds hitherto generally considered as "Upper Devonian."[4]

On the other hand, the opinion of Professor Dewalque on the marine origin of the "Cornstone Group" of Hereford, will afford surprise in some quarters.

In conclusion, allow me to make a correction of a clerical error in my paper. For "it," p. 531, line 11 from top, read "this division." Edward Hull.

Dublin, *Dec.* 14, 1878.

[1] "Possible Explanation of the North Devon Section," by Prof. E. Hull, Geol. Mag. December, 1878, p. 529.

[2] Brit. Assoc. Rep. 1877, Trans. of Sections, p. 69.

[3] Journ. Geol. Soc. Dublin, vol. vi. p. 227.

[4] "Siluria," 4th edit. p. 272. H. B. Woodward, "Geology of England and Wales," p. 69.

THE CALDER VALLEY.

Sir,—Mr. Davis's paper on the Valley of the Calder, in the number of the Geol. Mag. for November, 1878, is sure to be widely read; but I fear that some points in it are likely to be misunderstood by beginners in the study of geology. This must be my excuse for troubling you with any remarks on it, and I trust that my friend, the author, will for the same reason forgive any criticisms of mine.

Take the following sentences with reference to the Pennine Anticlinal and Blackstone Edge, viz.: "The thick beds of gritstone and shales were crumpled up like the leaves of a book, but being of a hard and very inelastic nature, the grit rocks were broken asunder, and we have the two faces of the separated rock considerably apart, in some instances the distance has to be reckoned by miles;" and again, "As the strata were successively strained and broken, they would gape wide apart at the centre of the arch; each bed of sandstone or shale, as it became elevated to the surface, would carry those which had preceded it further and further from the centre of rupture."

I think that these remarks are very apt, as they stand, to mislead young students into thinking that the opposing escarpments of each bed of grit, etc., as shown in the diagram, once *touched each other* along their *present faces;* and that the vacant spaces represent a gaping fissure instead of so much material removed by denudation. Of course, Mr. Davis does not mean this, but I fear that many readers will think he does.

Again, with reference to Stainmoor and the transport of granite boulders, we read that a branch of the great glacier "passed over Stainmoor into Wensleydale." Now, the pass of Stainmoor does not lead into Wensleydale, but into Teesdale. Wensleydale must have been written by mistake for Teesdale. But further, there are no granite boulders in Wensleydale. The whole discussion as to the transport of Shap granite boulders into East Yorkshire turns upon the fact that they did *not* travel by way of Wensleydale, but crossed over the lofty pass of Stainmoor, and that at such an elevation that there was nothing to prevent their also getting into Arkendale, and so into Swaledale, had they gone over on floating ice, as so many geologists have maintained. With reference to this I would refer to Mr. Goodchild's map and paper on the "Glacial Phenomena of the Eden Valley" (Quart. Journ. Geol. Soc. 1875, vol. xxxi. p. 55).

I do not know what river base Mr. Davis refers to as being "not far distant" from the Calder Valley; but, as to the latter valley having been submerged when the erratics found in its gravel, were transported thither, I wish Mr. Davis would give us his reasons for so thinking.

It would be a very interesting fact were it established or even rendered probable that the Calder Valley was submerged when its gravels were deposited; but I should like to hear the reasons for it before accepting it. The said gravels did not appear to me, when I was working in that country, to differ from ordinary river gravels; nor do I think it at all necessary to introduce the sea to account for the erratics found in those gravels; for the glacial drift with erratics lies on the Lancashire side so high on the hills close up to the watershed, and so much above the summit level of the low pass between Todmorden and Rochdale, that I think erratics may very well have been washed down out of the glacial beds into the Calder Valley by ordinary rain and river action.

I am also puzzled by the statement, "You may always be sure that, wherever heather and peat occur, the rock below the surface is sandstone. You will never find the heather growing on a bed of limestone, or shale, or clay, but always on sandstone." I have myself noticed that peat is very often, not to say generally, underlain by a bed of yellowish clay, which forcibly reminded me of the underclay of a coal-seam. J. R. Dakyns.

H. M. Geological Survey, Bridlington Quay.

CHLORITIC MARL AND UPPER GREENSAND.

Sir,—Will you allow me to make a few observations in reply to Mr. C. J. A. Meÿer's "Notes respecting Chloritic Marl and Upper Greensand," which appeared in the Geological Magazine for December, 1878.

Let me in the first place thank Mr. Meÿer for pointing out the probability that Captain Ibbetson included two distinct beds "in actual contact, but *widely separated in age*," under the term Chloritic Marl. The idea had not occurred to me, and I have not had an opportunity of refreshing my recollection of the Isle of Wight sections since I took up the question of the Chloritic Marl; it would seem, however, to be a very probable supposition, but assuming it to be correct, I fail to see how it improves Mr. Meÿer's position. On the contrary, it appears in my opinion to form a still greater objection to the classification proposed in his paper on the Cretaceous Rocks of Beer Head.

Mr. Meÿer maintains that he was correct in correlating beds 10 to 12 of that section with Ibbetson's Chloritic Marl, *i.e.* with what he himself defines as embracing "the (local) top of the Upper Greensand and the (local) bottom of the Chalk Marl of the Isle of Wight." Now, granting for the moment the correctness of this correlation, he has surely committed himself to a classification that cannot possibly be retained. If, indeed, these are the beds which were originally united under the name Chloritic Marl, it becomes very clear that such an application of the term cannot any longer be admitted, and with it, therefore, must fall also Mr. Meÿer's nomenclature.

Whatever was the original signification of Chloritic Marl (and I think the question is likely to remain rather obscure), I still believe that it was the glauconitic base of the Chalk Marl only to which the term was applied by most subsequent observers. Mr. Meÿer must excuse me for pointing out that the instance he gives to the contrary hardly goes for much, since Forbes was associated with Ibbetson in the original description of Chloritic Marl, and the memoir referred to was written by Forbes in 1850, a year only after the publication of Captain Ibbetson's Notes. It is possible, however, that the Chloritic Marl of the Geological Survey Memoirs, issued in 1862, was the same as that of Captain Ibbetson, but more recent writers have certainly taken it in the more limited sense.

Again, Mr. Meÿer asks, "was I wrong then in suggesting the separation of beds 10 to 12 from the Upper Greensand, and applying to them the term Warminster Beds?" Now, there are two questions involved in this sentence which should be carefully distinguished. These are—

(1). The separation of the said beds from *the rest* of the Upper Greensand.

(2). Their separation from or inclusion in the formation usually known as the Upper Greensand.

As regards the desirability of the first, we are all agreed, and Mr. Meÿer has been duly credited with being the first to recognize the distinctness of the fauna.

With respect to the second point, it depends of course on the application and definition of the term "Upper Greensand," and I confess that I do not see the force of Mr. Meÿer's reasoning on this head.

Surely, if we are to retain the name Upper Greensand at all, it should include all the strata which follow, in unbroken succession, from the top of the Gault (wherever that line is drawn) to the base of the Chalk Marl, where there is a distinct break in the series. This was its original application, and if we have eventually to recognize more life-zones than those at present indicated, why may they not all be included under the one comprehensive term?

Mr. Meÿer distinctly limits the "true Upper Greensand" to the strata between the Blackdown and the Warminster Beds, thus reducing it to mere zonal importance. I contend, on the other hand, that it is better to retain the name in its original signification, and to give it the rank of a divisional formation.

The answer to Mr. Meÿer's second question is, I think, contained in his own "Notes." He asks, where is there a Warminster fauna in the Upper Greensand? The answer is given at the bottom of the same page; speaking of the conglomerate occurring on the line of division between the Upper Greensand and Chalk Marl, near St. Catharine's Down, he rightly says that it divides two faunas, "the lower of which includes *Pecten asper*, *Terebratella pectita*, *Catopygus columbarius*, *Galerites castaneus*, and various other Echinoderms." Is not this a Warminster fauna, and is it not in the "local top of the Upper Greensand," whatever the bed might formerly have been called?

Having now replied to Mr. Meÿer's queries, I should like to ask him two questions in return. (1). Why has he changed his mind regarding bed 13, and why does he not identify it with the zone of *Belemnites plenus?* (2). What does he mean in saying that he was *therefore* wrong in giving *Holaster subglobosus* so wide a range in his tables of fossils? Is it not found in the beds where he marks it as occurring?

Finally, I may express my satisfaction at finding that Mr. Meÿer admits "that the term Chloritic Marl is and always has been a bad one," and I hope he will ultimately agree with Mr. Whitaker and myself in advocating the entire abandonment of the name.

Dec. 16th, 1878. A. J. Jukes Browne.

II

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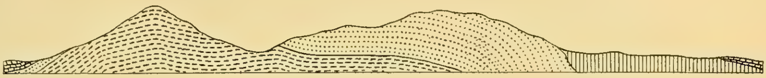
MAP
shewing Soundings between the
LANDS END AND THE SCILLY ISLES
(To illustrate Mr. W. A. E. Ussher's paper)
5 Fathom Line
10 " do "
20 " do "
25 " do "
30 " do "
35 Fathom Line
40 " do "
45 " do "
50 " do "
Soundings of 90 Fathoms 90
Depths under 5 Fathoms
Depths of 40 to 50 Fathoms
Depths of more than 50 Fathoms
30'
6.0'
30'
50°
90
St. Ives
Zennor
Lelant
Hayle
Trecobben Hill 590
Castle an Dinas 754
Pendeen Cove
St. Just
Cape Cornwall
Madron 381
St. Hilary
Marazion
Perlinney 717
Penzance
St. Michael's Mt.
Newlyn
Chapel Carn Brea 649
Buryan 409
Land's End
Seven Stones
St. Martins
St. Marys
SCILLY ISLES
Wolf Rock
VARn. 22° 5' W.
MAGNETIC

Fig. 1.



Diagrammatic Section from N. to S. to show general structure of District.

Fig. 2.

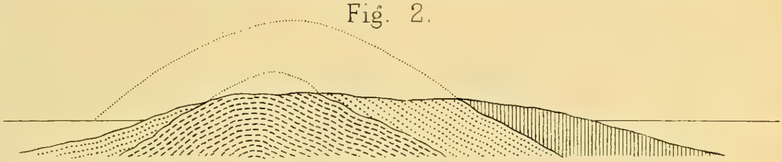


Diagram to show Plateau of Marine Denudation at close of old Red Period.

Stanford's Geog.l Estab.t, London

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

THE
GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE II. VOL. VI.

No. II.—FEBRUARY, 1879.

ORIGINAL ARTICLES.

I.—On the Physical History of the English Lake District. With Notes on the Possible Subdivisions of the Skiddaw Slates.

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

(PLATE II.)

Introduction.—In previous papers upon the Geology of the English Lake District, which I have had the honour of laying before the Geological Society, special considerations of theoretic significance have been dwelt upon, and in the official memoir upon the Geology of the northern part of the English Lake District, detailed facts have been brought forward and a sketch given (in chap. xii.) of the original relation of the formations to each other, and their physical history. I yet venture to think, however, that there is need of a general summary of the facts relating to Physical History which may reach a wider circle of readers than do the official memoirs, and which may stimulate further inquiries into this deeply-interesting subject. The following pages may therefore be regarded as a sequel to my former papers on the district, and in some measure as a last chapter to the story told thus far.[1]

Age of the District.

Our first inquiry is naturally—What is the age of this small mountain district of Cumbria? Do Scafell, Helvellyn, and Skiddaw stand up as modern products of the world's evolution, or are they very ancient monuments, bearing many hieroglyphics written by the finger of time? First then, if we sum up the rocky volumes at our disposal, we find the following geological formations represented :—

(*d*) Carboniferous and Basement Conglomerate.
(*c*) Upper Silurian and Coniston Limestone Series.
(*b*) Volcanic Series of Borrowdale.
(*a*) Skiddaw Slates.

Each of these series stands by itself, and is either separated from its neighbour by a long period of time, as is markedly the case between (*d*) and (*c*), and less so between (*c*) and (*b*), or by a decided change in physical conditions, as between (*a*) and (*b*).

[1] For a list of the author's papers on the district see Appendix at the close of this memoir.

About the Carboniferous and Upper Silurian[1] we know sufficient to be sure of their age as compared with the corresponding rocks of other areas; but it is doubtful whether we are right in assigning, unhesitatingly, certain definite ages to the series (*b*) and (*a*), and that, too, mainly on the strength of the occurrence in the latter of certain groups of Graptolites. The Skiddaw Slates *may* be considered to be of Lower Llandeilo age, as long ago surmised by Mr. Salter and believed by Professor Nicholson; but they *may* represent *several* of the subdivisions of the Welsh Lower Silurian, and I shall presently bring forward some physical evidence to show the possibility of this latter surmise. At any rate, this much is evident, that the mountain district of Cumbria is made up of rocks of great age, and we may consider all the material that now enters into the formation of our Lake District Mountains to have been formed ere the lowest beds of the great Carboniferous System were laid down, and at the present day the beds of Carboniferous Basement Conglomerate and overlying limestones, sandstones, and shales form a rough circular framework to the older and mountain-forming rocks of Silurian (or Silurian and Cambrian) age, as shown in the Sketch-Map (Plate II.). We will now consider in succession the physical conditions which probably prevailed during each succeeding period of the history of Cumbria, giving first the leading facts in short abstract, and then dwelling on the conditions which those facts indicate.

Part I.—Physical Conditions of each Period.

A.—*Skiddaw Slate Period.*

As the name indicates, many of the rocks formed during this period have now a slaty character. The total thickness of the whole series we do not know, for no defined base is met with; but there must, I think, be at least a thickness of 10,000 or 12,000 feet of beds included under the head of Skiddaw Slates. We will return to the consideration of possible subdivisions of this formation, later on.

Cleavage is undoubtedly a characteristic feature among the rocks of this series, and is best exhibited among the fine black slates of the west and south side of Skiddaw. In such slates it is sometimes exceedingly difficult to determine the original bedding, and where, as in many cases, a system of close jointage, and sometimes a species of secondary cleavage, occur, the task is made still more difficult, or quite impossible. These slates, representing old marine muds, are those beds which most frequently contain fossils—as Graptolites, a few Trilobites, Phyllopod Crustacea, etc. Sometimes interstratified with the black slates, and sometimes forming thick masses by themselves, occur bands and beds of sandy mudstone, sandstone, and coarse grit. The flags are frequently ripple-marked, and show worm tracks. The grit occasionally passes into a true conglomerate, with

[1] In conformity with Survey nomenclature used in previous work, I here call the series above the Coniston Limestone, *Upper* Silurian, and when speaking generally of the physical relations of one group to another, I use the term to include all under the head of (*c*).

pebbles of quartz, and fragments of black slate, accompanied sometimes by felspathic portions, giving it a somewhat ashy appearance. These conglomeratic characters more particularly prevail in a bed occurring high up in the Skiddaw Series, to be referred to hereafter (see large-dotted band in Map). Again, in the lower part of the series, gritty beds very largely prevail, as in Whiteside and Grasmoor (Hor. Sect. No. 2, *a*, p. 54), where there are some thousands of feet of such beds. Fossils are not abundant in the sandy or gritty beds, and indeed, with the exception of worm tracks, and some doubtful Graptolites in the *flaggy* parts, and a single obscure shell in the upper grit of Latterbarrow, none have been found.

Physical Conditions indicated.—In this 10,000 or 12,000 feet of deposits, we meet with no indications of deep-sea conditions, rather throughout of shallow-water and shore conditions. Judging from the way in which, generally speaking, the sandy and gritty beds thicken westwards, one would be inclined to infer that the current drift was from the west, and continental land not far off in that direction. To allow of such a thickness of shallow-water deposits, there must have been continual depression of the area of deposition, and the greatest thickness of gritty beds occurring in the lower part of the series accords well with the idea of such a slow depression taking place, and causing the gradual submergence of the neighbouring land, whence the coarser sediments may have been derived. The presence of the bed of grit high up in the series may have been the result of a special set of currents lasting for a short time, and distributing the current-borne material very irregularly, as is, indeed, clearly shown by the great variations in thickness of the bed. It is quite *possible* that this bed of grit may indicate either a cessation of depression and slight denudation of the previously formed deposits, or even a partial elevation accompanied by denudation. There is little or nothing, however, in the general course of this grit to indicate the presence of a marked unconformity, rather would it seem to point to some slight change of conditions in the depths of the area of deposition. In the south-west of the district, about Lank Rigg, and Latterbarrow, this grit is succeeded at once by volcanic deposits, the black slates of the summit of Skiddaw being entirely absent. This would seem to show that the volcanic forces came into play earlier in this direction than about Keswick, and as volcanic action is generally connected—in the first place at any rate—with movements of elevation, it may well have been that some such movements preceded and prepared the way for the deposition of the grit. The volcanic ashes laid down upon the grit of Lank Rigg and Latterbarrow contain many rolled pebbles of that grit, and the character of these early ashy beds is clearly such as to indicate submarine volcanic deposits. On the other hand, the very presence of *rolled pebbles* of the grit proves that sufficient time must have elapsed for the *consolidation* of the gritty deposit ere the volcanic beds were laid down. This leads us naturally and without break into the next period—that of great and long-continued volcanic activity.

B.—*Volcanic Period.*

The rocks deposited in the present area of the Lake District during the period coming between that of the Skiddaw Slates and that of the Upper Silurian are almost exclusively of Volcanic origin. They may represent a total thickness of about 12,000 feet. At the base of the volcanic series only are there intermixtures with rocks of an ordinary sedimentary character; here, where the junction beds are exposed, occur alternations of Skiddaw Slate and submarine volcanic deposits. The rest of the series consists of beds of volcanic ash and breccia with lava flows. The finer ash deposits are frequently well stratified and false-bedded. The breccia is of all degrees of coarseness, from a rock made up of fragments having the size of a sixpence or shilling to one containing blocks several yards in diameter. Conglomeratic ash occurs in one or two beds *near the base* of the series. Much of the variation in appearance among the beds of the ashy series is due to subsequent alteration, metamorphic action producing diverse changes, dependent, oftentimes, upon slight original differences in texture and composition—examples of *selective metamorphism.* The lava-flows are either good dolerites and basalts, or belong to a class more or less mediate between these and the more acidic group of lavas. As is generally the case among volcanic deposits, the various beds are more or less irregular in their range, showing instances of rapid thickening and thinning.

Physical Conditions indicated.—The presence of ordinary sedimentary beds interstratified among the volcanic deposits near their base; the occasional occurrence in this lower part also of conglomeratic ash; and the absence of both these peculiarities in the great bulk of the volcanic series, together with that of fossils in the bedded ashes,—all point to volcanic action commencing at the close of the so-called Skiddaw Slate period beneath the waters of the Skiddaw Slate sea, and the gradual passage from submarine volcanic conditions to those of terrestrial and wholly subaerial volcanos. At first sight it might seem that the regularly-bedded ashes running at intervals throughout the series, pointed to subaqueous deposition, but no one can ramble much around modern terrestrial volcanos without being struck by the frequent cases of fine stratification shown by the ash scattered around, whether deposited in the wet or dry state, and by the not infrequent cases of false-bedding. It may sometimes have happened also that extensive deposits of ashy material were laid down in large crater-lakes.

The centres of eruption are difficult to fix upon, as might be expected amongst volcanic remains of such antiquity. The boss of Castle Head, Keswick, almost certainly represents one such centre, and the best developments of lava-flows are all found occurring within an easy distance. It may be further remarked that since the lower part of the series contains the greatest thickness of lava-flows, it would seem that the chief emissions of lava were followed by long and continued ejections of ashy material. What the height of the old Cumbrian volcano or volcanos may have been, it is difficult to estimate; but volcanic deposits were accumulated to a thickness, in parts, of at least 12,000 feet, and the highest beds known (the fine, altered, almost flint-like ash of Great End, Esk Pike, and Allen Crags) are unsucceeded by any conformable series of sedimentary rocks; hence we know not how much of the products of the old volcàno has been lost, and, for aught we know to the contrary, an Etna in size may have once stood where now are the resting-places of quiet lakes. In this connexion it is interesting to remember how little of our miniature mountain district would be uncovered, could we transplant Etna bodily with its surrounding volcanic ejecta to the site of the present Lake District.

Note.—In my previous papers, read before the Geological Society, and in the Survey Memoir, I have given my reasons for believing that the several granitic areas of the district were not connected with the volcanic deposits as cause with effect. It may well be that one or more large centres of eruption now lie hid beneath the unconformable overlap of Upper Silurian and Carboniferous rocks.

Bb.—*Unrepresented Period.*

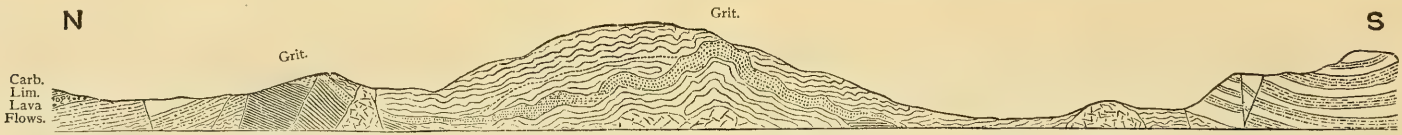
Between the periods indicated by *B* and *C*, there comes an interval of unknown duration which we may represent by *Bb.* This was a time of which we have no records left, but the duration of which is made clearly evident by records abstracted. It is as if the latter part of volume *B* was torn away, and hence we infer a denuding action subsequent to its completion.

Our Cumbrian Etna had ceased its activity, and, as so frequently happens, a subsidence of the volcanic region ensued, accompanied doubtless by much waste of the volcanic material through the agency of atmospheric denudation. Subsidence, however, continued until the old volcano came within the planing power of marine coast-action, and at last there was probably but little of the old terrestrial volcano left above the level of the sea.

For Cumbria, this is undoubtedly the point at which one would draw the line between Lower and Upper Silurian. Here is a great physical break, and the deposits accumulated above the Volcanic Series are markedly transgressive in their strike to those of that series, though, undoubtedly, for a *certain* distance east of Coniston, the strikes do more or less correspond. West of Coniston, however, nothing can be clearer than the successive curving round in strike of the divisions of the Volcanic Series and their abutment at right angles against the outcrop of the Coniston Limestone and Upper Silurians.

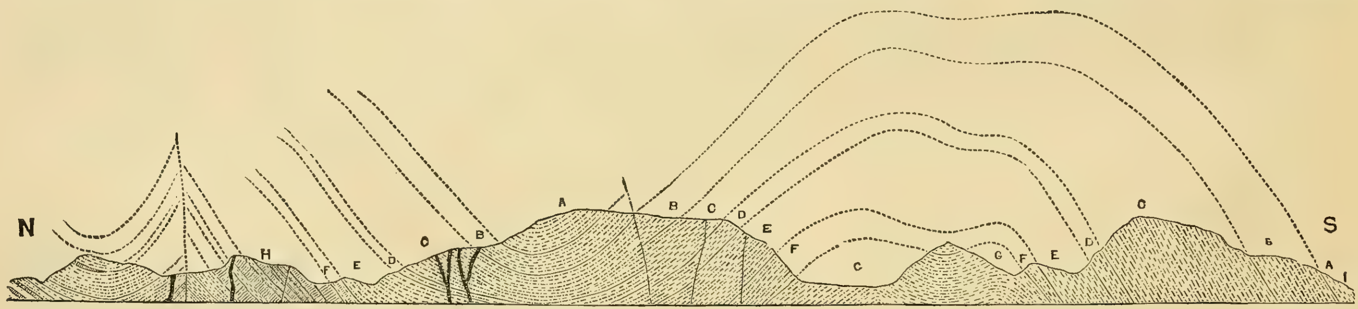
The period unrepresented by deposition, but made clear through denudation, was brought to a close by the formation on the bed of that Mid-Silurian sea of a deposit of limestone (the Coniston), rich in the remains of marine life. But here we meet with evidence of a slight return of volcanic conditions, and mingling with the calcareous deposit a bed or beds of lava were poured out. This time, however, the lava belongs decidedly to the more highly silicated group, and the felstone now associated with the Coniston Limestone

To illustrate Rev. J. Clifton Ward's Physical Geology of the English Lake District.



Hor. Sect. No. 1.—Section through Skiddaw.

Hor. Sect. No. 2.—Section through the Skiddaw Slate Series.



Hor. Sect. No. 3.—Section through the Volcanic Series.

A. Yewdale Breccia. B. Bedded Volcanic Ash. C. Volcanic Ash and Breccia. D. Highly Altered Bedded Ash.
E. F. G. Highly Altered Volcanic Rocks. H. Series of Lava Flows.

N.B.—The scale (1 inch to 1 mile) has been slightly altered to suit size of page.

probably represents an ancient quartz-trachyte. With this slight indication of dying volcanic power over the tract under description, commences another great series of marine depositions quite unaccompanied by volcanic phenomena.

C.—*Upper Silurian Period.*

Under this heading I will also include the time during which the Coniston Limestone and associated beds were being formed; *physically*, in this district, these deposits belong to the Upper Silurian, although, palæontologically, they may be the equivalents of Welsh *Lower* Silurian divisions.

According to Mr. Aveline's determinations, in the Kendal district the total thickness of these Upper Silurian beds cannot be less than 14,000 feet. At the base of this great series lies the only limestone bed—that of Coniston—and throughout are alternations of clayey and sandy deposits, the former much cleaved and folded, and the latter occurring as flags, sandstones, or grits.

Whether there be a slight unconformity or not between the Coniston Limestone Series and the great overlying group of Coniston Flags, *practically* the whole forms one continuous succession of sedimentary deposits.

Although no Upper Silurian beds are found north of their Coniston and Windermere outcrop, there is every reason to believe that the whole series once extended over the now exposed volcanic rocks, for there is nothing in the deposits themselves to indicate a land margin near their present outcrop.

Physical Conditions indicated.—Such a thickness of beds as that just described implies a continued slow subsidence of the sea-bed during the whole period of deposition. The character of many of the strata decidedly points to shallow-water formation, though it is hard to say from what direction the material was derived. The conditions correspond in great measure to those prevailing during the Skiddaw Slate period; when, however, the uppermost Silurian beds had been deposited, the Skiddaw Slates must have been buried some 20,000 to 25,000 feet deep, beneath the piled-up volcanic series and the great accumulation of Upper Silurian strata.

Cc.—*Unrepresented Period* (*Old Red*).

Again we come upon a period of time unrepresented by written records, but clearly evidenced by the destruction of the records of the previous periods. This destruction by denudation was carried on to an enormous extent, being accompanied, or rather rendered possible, by great movements of upheaval over the whole tract, which movements were probably most intense along a N.E. and S.W. axis, running through the heart of the present *mountain* district. If we pile up black cloth in layers to a thickness of ten inches, red cloth upon this to a thickness of twelve inches, and blue cloth upon the red fourteen inches thick, then by bringing some powerful force to bear upon the two ends of the pile, the whole may be thrown into curves and contortions by the lateral pressure, and the centre portions consequently raised above the level of the ends. Imagine, then, a large pair of shears brought forward which shall cut off or pare down all the upraised central portion; in this way the uppermost blue cloth may be removed altogether from the centre of the low arch, a less amount of the red cloth layers would be removed, while, perhaps only a few topmost inches of black cloth would be touched, but the consequence would be that, at the centre of the cloth dome, an arch of black cloth would appear, on either side of this would lie inclined layers of red cloth, to be flanked in their turn by similarly inclined strata of blue cloth. Suppose, now, the ten inches of black cloth to represent 10,000 feet of Skiddaw Slates, the twelve inches of red cloth 12,000 feet of Volcanic Deposits, and the fourteen inches of blue cloth 14,000 feet of Upper Silurian strata; suppose, moreover, the lateral pressure applied at either end of the cloth to signify a probable depression of extensive tracts on either side of that over which these formations are upraised, and the gnawing and planing action of the sea along the coast-line of rising land, aided by the powers of the atmosphere, to be represented by the great shears, then, when the elevation and crumpling had done their work, and brought the pile of 36,000 feet of strata conveniently under the denuding agents, some of the outer coats of this dome must have been pared away, and Upper Silurian and Volcanic deposits being both removed over the central dome, the Skiddaw Slates themselves would be once more exposed to view (see Plate II., Fig. 2). Such a denudation must mean the removal of 20,000 to 25,000 feet of strata, unless we suppose that within the distance of *a few miles* (twelve or fourteen) the thickness of the Upper Silurian beds was much reduced. To this amount of removed material we must add a considerable thickness of Skiddaw Slates, themselves cut from the dome top. Surely such an action must represent a very great length of time, yet do we find that it all transpired in the interval between the close of the Upper Silurian and the deposition of the Red Conglomerate of Mell Fell, ushering in the great Carboniferous Period. For these Lower Carboniferous rocks (Mell Fell Conglomerate, etc.) are deposited across the denuded edges of all the older formations; at one place they lie upon Upper Silurian, at another upon rocks of the Volcanic Series, and at yet another upon the Skiddaw Slates. Thus there cannot be the shadow of a doubt as to the length of time which must have elapsed between the close of the Upper Silurian and the commencement of the Carboniferous Period, and of the greatness of the work accomplished in that time.

It is to the earlier part of this lengthy period, when the Skiddaw Slates were buried at their deepest, and internal commotions began to be displayed, that I would assign the formation of the various granitic centres. In an earlier paper I have treated of the probable pressure under which they were respectively formed, and called attention to the fact—in the Survey Memoir (p. 74)—that an axial line of most intense metamorphism runs parallel with the main axis of upheaval. That there was a disposition at this period towards volcanic outburst I do not doubt, and that the mass of the Shap Granite came nearest to establishing a volcanic connexion with the surface I have hinted before; but we have no evidence that the granitic roots were ever continuous, in this district, with volcanic vents, though, having no deposits of the true Old Red age (Lower Old Red) in the district, it would be unsafe positively to say that there were not volcanic eruptions within this area in Old Red times, or that the Shap Granite, for example, does not represent the root of such an Old Red volcano. Of the three principal granitic centres (see Sketch-Map, Plate II.) the Skiddaw granite occurs only in connexion with the Skiddaw Slate, which is extensively metamorphosed around, but the granite, *where we now see it*, is undoubtedly intrusive; the Eskdale Granite ranges for a distance of more than fourteen miles through the Volcanic Series, and is surrounded by an extensive zone of altered volcanic rocks; while the Shap Granite has altered both volcanic rocks and the Coniston series. We have, in fact, in these three masses, granite consolidated at various depths, or the *potential* roots of volcanos exposed at different stages.

We shall return to consider the probable length of time represented by the effects of denudation during this period, when the chronology of the district is discussed.

D.—*Carboniferous Period.*

Under the head of Carboniferous I include the beds in this district formerly classified as Old Red, but which have been shown to be but the Basement Conglomerates of the Carboniferous. These conglomerates are particularly well developed in Mell Fell (1760 ft. high), and the range of hills extending eastwards from that mountain to the foot of Ullswater (see Sketch-Map). Their general character is that of a loose sandy matrix containing pebbles of all sizes and occasional large and more angular blocks as much as three feet in length. In parts the larger pebbles are absent, and the beds take on the character of a coarse grit, always much false-bedded. The peculiarity of this conglomerate consists, however, in the composition of its pebbles. In Mell Fell they all seem to belong to sedimentary rocks, and are composed of gritty and micaceous sandstone similar to that so largely occurring in the Upper Silurians (Ludlows) of the Kendal district. Although Mell Fell, rising to a height of 1760 ft., stands partly on Volcanic ground and partly on Skiddaw Slate, and must have once extended much further to the west and even nearer to the mountains formed of volcanic rocks, yet I have failed to detect one undoubted instance in the conglomerate of this hill of a pebble made from these rocks. At Pooley Bridge (foot of Ullswater) a few cases occur of ash and trap pebbles, though those of sandstone and grit largely predominate. At Hutton, however, two miles to the east of Mell Fell, there are many pebbles of ash and trap and of altered Skiddaw Slate, occurring with those of sandstone. It is worthy of remark that the pebbles of trap at Hutton most resemble the lava flows of Eycott Hill two or three miles to the north-west (just N. of the railway line). In most cases the pebbles, and even the large angular blocks, lie with their long axes in the direction of the bedding. The pebbles are frequently rather elongated and often flattened at the sides. In some few cases these flattened sides seem to bear scratches like those left by glacial action.[1] Such are the chief facts with regard to this Basement Conglomerate, their possible meaning will be considered directly.

The various beds of limestone, shale, and sandstone which go to form the Carboniferous framework of the district come in above this very irregularly distributed conglomerate. Some of the lower beds of limestone contain quartz grains and small pebbles. Generally speaking, there are very frequent alternations of limestones and sandstone, with occasional shale bands and thin coal-seams. The limestones are often highly fossiliferous and largely made up of corals.

No volcanic ashes or lavas are found in connexion with the Carboniferous rocks immediately surrounding the mountain district. Lavas, basaltic in character, and often highly vesicular, occur beneath the limestone all round the northern side of the framework, from Cockermouth to Eycott Hill (see Sketch-Map), and could one not prove by fairly conclusive evidence that they belong to the northern extension of the Borrowdale Volcanic Series (on the N. side of the anticlinal), they might readily be taken for Carboniferous basalts, such as occur among the Carboniferous rocks in plenty upon the other side of the border.

In one case only do igneous *intrusions* occur among Carboniferous rocks immediately skirting the district, and that case is among the basement conglomerates just east of Little Mell Fell. Four very small bosses of basalt, wrapped round by hardened conglomerate, and showing vesicular margins, may be seen close to Mell Fell farm. That they are intrusions there can be no doubt, and microscopic examination reveals their likeness to the basaltic dykes of the Pennine range—a likeness which is also sufficiently evident in hand specimens.

Physical Conditions indicated.—What was the condition of our present mountain tract during the great Carboniferous period? Was it wholly submerged after the elevation and denudation to which we have already seen it subject, or was there always a nucleus of dry land —an embryo of Cumbria—around which the Carboniferous deposits were laid down? I do not think this is a question that can ever be decidedly answered. Long ago it was remarked by Prof. Sedgwick, that "had our island been laid dry immediately after the Carboniferous period, without any change of relative position among the great formations, the Cumbrian mountains would have appeared as a cluster of ancient rocks rising out of a great Carboniferous plain."[2] That the limestone beds extended much farther than their present outcrops, cannot be doubted; but whether the elevated and denuded block of Silurian strata was ever completely smothered under Carboniferous deposits, may fairly be questioned. At first sight one would naturally suppose that the existence of thick masses of Basement Conglomerate would clearly point to shore

[1] Some such apparent ice-scratched stones from Mell Fell have been deposited in the Jermyn Street Museum.

[2] Trans. Geol. Soc., second series, vol. iv. p. 47.

action; but while these beds do thus indicate shallow-water conditions, and the presence of powerful currents around some land, yet the material—in the case of Mell Fell,[1] etc.—is not derived from the neighbouring Lower Silurians, but won from Upper Silurian strata, which in the area around Mell Fell must have been denuded away long since, for, be it remembered, these conglomerates are laid down partly upon Volcanic rocks and partly on Skiddaw Slate (see Map), and the latter could not have been exposed until long ages after the Upper Silurians had been removed.

Since the Mell Fell Conglomerate must have had at one time a much greater westerly extension, and since it now occurs up to a height of 1760 ft., the Cumbrian nucleus must have been small, though to what height it attained cannot be estimated. But what could cause the peculiar composition of the conglomerate? Why should it not be made up of stones worn from the neighbouring land? This is a puzzle. Was there no such neighbouring land formed of *Lower* Silurian rocks? Then why should there be exposed *Upper* Silurian beds—whence the pebbles were worn—laid bare at some point which one would infer, from the facts of denudation previously discussed, to be at a distance from the principal centre of upheaval—farther from the axis of elevation and disturbance (Plate II. Fig. 2). If Upper Silurian beds, forming the sides of the anticlinal, were exposed, surely there is every probability that some land existed nearer to the centre of upheaval. This anomalous distribution of the material of the Conglomerate led me at one time to speculate on the possibility of the Upper Silurian sandstone pebbles having been drifted by current action "around the skirts of a tract of high land, which, not rising in any lofty peaks, was effectually protected from marine and subaerial denudation, at that particular time, by an icy covering, leaving few or no rocks exposed above its surface."[2] Even then it is hard to understand how ice-borne scratched stones from the Lower Silurian high ground did not *freely* mingle with the current-drifted pebbles of sandstone. Again, how is the *great development* of conglomerate between Mell Fell and Pooley Bridge to be accounted for? It would seem to thin away very rapidly, both north and south, but especially to disappear northwards. Can it have accumulated in an old valley[3] or fiord, or in a narrow channel? If in the former, how came it to be filled with material foreign to the surrounding land? If in the latter—a channel or strait—may not the Mell Fell deposits occupy the site of the eastern end of a strait, which at that early period had been sketched out as the future great valley separating the Skiddaw and Blencathra group of mountains from the more southern mass of land.[4] In this case one might understand the banking up of shingle

[1] Mell Fell is a mountain of rounded form at the west end of the long patch of Conglomerate marked on the Sketch-Map, Plate II.

[2] Survey Memoir, p. 76.

[3] Prof. Phillips long ago suggested that the Old Red—so-called—may have been accumulated in old valleys.—Geology of Yorkshire, vol. ii. p 14.

[4] The east and west line of railway on the Map may be taken as the axis of this now much-deepened channel.

against the eastern end of the channel, and much of it might have been rolled well into or through the strait. The subsequent great deepening and widening of this channel to form the present broad valley may easily have removed all traces of the further westerly extension of the conglomerate. (The base of the conglomerate at Mell Fell stands at about the 1000 ft. level.) This might account for the great local thickening of the conglomerate along an east and west line, although of course its present distribution in the form of a band, two miles wide and some five in length, is due partly to the overlap of the limestone on the north and east, and in the south its boundary appears to be mostly a faulted one.

I should be inclined to think that on the whole it was most likely that the drift of Upper Silurian pebbles was from the south, round the skirts of the land-nucleus by Shap and Bampton, until, the current being deflected up the eastern end of the early Keswick Vale strait, the material might be there banked up and prevented from being carried further north, partly by the set westwards up channel, and partly, perhaps, by more or less of a bank on the north side of the mouth of the strait. Certain it is that north of the present line of railway (between Keswick and Penrith) the conglomerate is almost entirely absent.

My former supposition as to the land-nucleus being covered with an ice-sheet I regard as very doubtful, but one cannot but be surprised at the scarcity of pebbles derived from the Volcanic series, although, as I have remarked, they are more numerous at some spots than others. It may have been that cold conditions prevailed, as rather indicated by the character of some of the stones in the conglomerate (the apparently flattened and scratched stones, and the large and more angular blocks) ; but if cold prevailed, and ice and snow were at work upon the land, one might have expected to see more indications of their action in the shore deposits. There is, however, another fact which rather strongly militates against the idea of a glacial climate having prevailed at this time. North of Carlisle, all along and over the border, there occurs a great development of the Calciferous Sandstone Series, consisting of many thousands of feet of beds below the true Limestone Series of Cumberland, as developed east of the Lake District. This great thickness, gritty sandstones in the upper part, and thin limestones and shales with occasional coal-seams in the lower part, must, one would suppose, have been in course of deposition during the period of formation of the so-called Basement Conglomerate, and, perhaps, long anterior to the commencement of its formation. Now these beds show no signs of glacial conditions, the lower part (thin limestones—with ordinary Carboniferous Limestone fossils,—shales, and a few coals) indicates similar conditions to those prevailing during the rest of the Carboniferous—sometimes marine, sometimes fresh-water, sometimes terrestrial—and the upper part consists mostly of thick gritty sandstones containing thin calcareous bands, and occasional coal-seams with shale. Hence we must suppose either that (1) previous to and during the formation of the Mell Fell Conglomerate, rocks of a Carboniferous type were being deposited in the border-area under ordinary Carboniferous climatal conditions; or (2) that the Conglomerate was deposited when glacial conditions prevailed, and that a long period elapsed between its formation and that of the true Limestone Series, during which period the Lower Carboniferous of the border-land and of Scotland was formed under warmer conditions. Now against this latter supposition is the fact that there are often indications of a true conformable junction between the upper part of the basement-beds and the overlying limestones; therefore, if there is no break between the Basement Conglomerate and the Limestone series, and no break between the Lower Carboniferous Calciferous Sandstone series and the same Limestone series, the Conglomerate and the Calciferous Sandstone series must be considered as more or less contemporaneous formations, and the doubtful glacial indications among the Conglomerate are negatived by the general Carboniferous facies of the climate indicated among the Calciferous Sandstone series.

All that has now been said about the origin and formation of the Mell Fell Conglomerate inclines me to think that, at all events during the early part of the Carboniferous Period, there must have been a land-nucleus, a Cumbria in embryo; but whether this early centre was or was not covered over during the later part of the Carboniferous Period by deposits of limestones, sandstones, and shales, is one which must be left open. Certainly, the *general* absence from the limestone series immediately surrounding the district of material such as would have been derived from a tract of land formed of the Lower Silurian rocks, is in favour of a complete submergence during the *latter* half of the Carboniferous Period. Surely, if the present outcrop of the limestones, etc., immediately around the Lake District, be not *far* removed from their termination along a shore-line, one would expect, at any rate, to find water-worn débris won from the hard rocks of the Volcanic Series. May we not, therefore, rather believe that after the great elevation and denudation of the Silurians of the district which took place in Old Red times proper, the Mell Fell Conglomerate was formed at the mouth of an inlet or *strait* running into or through the northern portion of the early land, and that subsequently that early land was wholly or almost wholly covered up by Carboniferous deposits as it once more slowly sank beneath the waters of the sea. The close of the Carboniferous Period was probably marked by an upward movement over the area of the present Lake District, a movement during which the denuding powers must have largely stripped off the outer Carboniferous skin, laying the old Silurian nucleus bare, never again to be covered up by unconformable measures. This elevatory movement was probably coincident with that great east and west one forming the Pendle Anticlinal.

(*To be Continued.*)

II.—On Supposed Fossiliferous Pliocene Clays overlying Basalt, near the Shore of Lough Neagh.

By William Swanston, F.G.S., Belfast.

IN the Geological Magazine for December, 1876, appeared a short paper on certain clay beds near the south-eastern shores of Lough Neagh. The paper is intended to supplement a more extended communication entitled, "On the Age and Mode of Formation of Lough Neagh," read by the same author—Edward T. Hardman, Esq., F.C.S., H. M. Geol. Survey of Ireland—before the British Association in 1874,[1] and also read before the Royal Geological Society of Ireland in January, 1875.[2] The beds in question are described "as a very extensive and important deposit, spreading (under water and on shore) over an area that cannot be less than 180 square miles in extent, and probably in some places 500 feet thick. They repose on the basalt, and are covered by drift. All the evidence we have points to their being of Pliocene age." The author, after giving a sketch of the Geology and Physical Geography of the district, proceeds with a description of the clay beds and associated lignites, and gives abstracts of numerous borings ranging in depth from a few feet to 192 feet, which have been made over this area. These borings disclosed a series of light-grey and variously-coloured plastic clays, containing hard nodules of clay-ironstone inclosing leaf and other plant-remains, also large quantities of black lignite, occurring frequently in masses throughout the beds, but sometimes bedded.

From the fact that no visible junction was known between the clays and the rocks upon which they repose, much elaborate argument was brought forward to prove that the former were of later date than Miocene, and rested on the surrounding basalt of that age. Hitherto no fossils except plant-remains had been found in them, and, in the absence of more direct evidence, they were considered to be of Pliocene date. The subsequent discovery[3] of fossil shells in a clay band on the banks of the Crumlin River, and which clay band was supposed to rest in this place directly on the basalt, seems to have proved to the satisfaction of the author of the paper, and to Professor Hull, F.R.S., who examined the section at the same time, that the beds were undoubtedly of Pliocene age.

Owing to the extremely delicate structure of the shells, and the friable nature of the bed in which they occur, it is most difficult to obtain good specimens; those procured by Mr. Hardman were admittedly in so bad preservation that Mr. W. H. Baily, F.G.S., to whom they were submitted, would not do more than express an opinion regarding them, than that they may *possibly* belong to a new species. The author, however, seemed to be convinced that they belonged to a species of *Unio*, not unlike *Unio Solanderi* of the Upper Eocene of Hordwell Cliff, Hampshire; and is so far satisfied

[1] British Assoc., Trans. of Sections, p. 79.
[2] Journ. Royal Geol. Soc. of Ireland, vol. iv. part iii. new series, p. 170.
[3] Geological Magazine, December, 1876, Decade II. Vol. III. p. 556.

regarding their character, and the age of the containing beds, that he concludes his paper by remarking, in the absence of better specimens, that, "In the meantime it is right to place the matter on record—seeing that this place is, so far as I know of, the only locality in the British Isles yielding *lacustrine* fauna of *Pliocene* date."

During the past summer, in company with a few other *amateurs*, I made frequent visits to the Crumlin River, and succeeded in procuring better examples from the same clay beds than had apparently been obtained before. As the opinion formed from the inspection of the fossils on the spot, and from other independent evidence, is entirely different from the conclusions arrived at by Mr. Hardman, not only as regards the shells, but also respecting the age of the beds; and as considerable importance has been attached to the determination of the shells as indicative of a Pliocene lacustrine fauna in Britain; I had a good series of them prepared and sent to Dr. J. Gwyn Jeffreys, F.R.S., for his opinion regarding them. That gentleman, with his usual kindness, states, "I can come to no other conclusion than that they are certainly not any species of *Unio*, but belong to our common mussel (*Mytilus edulis*).[1] which occurs in all the newer tertiaries. The structure, composition and colour agree (See British Conchology, vol. ii. p. 103.)"

A quantity of the material from the same shell-bed was submitted to Joseph Wright, Esq., F.G.S., of Belfast, for microscopic examination. Mr. Wright reported that the only microzoa that he was able to detect in the clay were a few foraminifera, referable to four species, namely :—

Globigerina bulloides, D'Orb.—very rare.
Textularia variabilis, Will.—small, and very rare.
Discorbina globularis, D'Orb.—rare.
Nonionina depressula, W. and J.—common.

The foraminifera above enumerated are all found living and in abundance on our coasts, and are also species which are of frequent occurrence in our Drift-beds; the last mentioned, especially, is a very common Boulder-clay form.

The coarse material left after the examination for microzoa, consists for the most part of small round pieces of clay, which were too hard to dissolve in the washing. There were also a good many fragments of lignite, and one piece of silicified wood about an inch in length.

An examination of the stratigraphical position of these fossiliferous clay-beds proves that they repose upon a deposit of true Boulder-clay, the position of which is accurately represented in the section illustrating Mr. Hardman's paper,[2] and is there described as follows: "*m.* Coarse gravelly clay—pebbles of quartz and basalt—resting in pockets and erosions of basalt = 3 feet." This coarse gravelly clay is of a dark brown colour, extremely compact, and full of large

[1] This confirms the opinion expressed by the Editor of the Geol. Mag., that the fossils shown him by Mr. Hardman indicate rather a *Mytilus* or *Modiola*-like shell than a *Unio*.—See Geol. Mag., December, 1876, foot-note, p. 557.

[2] Geol. Mag. 1876, Decade II. Vol. III. Pl. XXII. Fig. 1; and Journ. Royal Geol. Soc. of Ireland, vol. iv. part iii. new series, pl. xii. fig. 1, etc.

stones and pebbles; so compact is it, that it is with difficulty the larger stones can be removed, but when taken out they almost all exhibit the well-known form of glacial pebbles, and very many of them retain quite distinctly the characteristic scratching and polishing due to ice action. The miscellaneous character of the stones and pebbles is also worthy of note. The following were noticed, beginning with the most numerous and proceeding in the order of their relative abundance:—Basalt (local), chalk and flint (Antrim), sandstone and clay nodules (New Red Marls?), quartz, mica-schist, granite (red), etc. There is also a great abundance of lignite, in pieces from several inches in length to mere particles, scattered irregularly through the bed, and I was fortunate enough to find a piece of grey siliceous sandstone containing plant-remains, principally dicotyledonous leaves resembling those of the beech and willow, and closely agreeing in character with the siliceous nodules which occur in the plastic clay of Lough Neagh.

The only conclusion that can be drawn from the foregoing is,—that the beds in question containing *Mytilus edulis* and Foraminifera are of marine, or, at least, of brackish-water origin. The common mussel is at present found living from high-water to a few fathoms in depth, and it is also found in tidal rivers, but never entirely out of reach of the sea. Judging from the appearance of the fossils in the clays, I am of the opinion that the animals lived and died where we now find their remains; or that they have, at least, suffered very little disturbance. In many of them the valves are united and the epidermis still preserved. Foraminifera are essentially marine organisms; a few only are known to inhabit brackish water. The species detected in the clays in question indicate a depth of at least a few fathoms, and may be found in almost every haul of the dredge on suitable ground around our coast at moderate depths.

The fact that the fossiliferous deposit reposes upon true Boulder-clay containing well-marked glacial pebbles, at once proves that it is *not of Pliocene age*, but either a Glacial or a Post-Glacial deposit. The settling of this question would require further investigation than has yet been given to the subject. The error into which Mr. Hardman seems to have fallen, was, in hastily concluding that the Crumlin River beds were identical with the beds of white clay, lignite, etc., which occur along the southern shores of Lough Neagh, whereas the latter beds do not seem to extend to within half a mile of the spot where the fossils occur, nor do they in any way resemble them in lithological character.

What then is the age of the Lough Neagh clays and their associated lignites, which are estimated as covering an area of 180 square miles and to be in some places probably 500 feet thick?

Granted that they may repose upon the basalts—they may be of any age between that to which the lower sheets of the Miocene beds of the neighbourhood belong, and the clays of the Glacial epoch with which the upper beds are undoubtedly associated. In all probability they span the entire period, and are in part contemporaneous with the lacustrine iron-ores, beauxite, and lithomarge of the Antrim

Hills, which also rest on the same basalts, and contain plant-remains similar in general character to those in the Lough Neagh clays. In the absence, however, of full lists of the flora of both beds, nothing more definite can at present be stated regarding their identity. Should subsequent researches prove them to be the same, it may safely be inferred, that one reason why the Lough Neagh beds still retain their clayey character is owing to the simple fact that the *later* outflows of Miocene basalt did not reach them, and convert them into iron-ores, etc., similar to those so largely developed to the east and north of County Antrim.

Although not strictly connected with the subject, I may be allowed to refer to the much-vexed question of the origin of the silicified wood of Lough Neagh. Dr. Barton was most probably right in his statement, made in 1751,[1] that the celebrated fossil-wood was found in association with the black lignites. His descriptions of over a hundred specimens—many of them figured in his work, most of which were part wood and part stone—cannot be ignored; and although only a few of these were obtained direct from what seemed to be the true Lough Neagh beds, yet many were so intimately associated with the lignite, the origin of which is not disputed, that considerable weight still attaches to his quaint descriptions.

I have in my possession specimens, portions of which still retain their woody character, in no way different from the more solid pieces of lignite. One piece was found intimately associated with the lignite and white-clay beds; and in the same place was also found one of the numerous ironstone nodules, derived from the same clays, which contained a piece of silicified wood and other plant-remains. Scattered through the Boulder-clays of the district for miles around may be found pieces of the lignite, which testify to the vast amount of denudation which the older beds have suffered. Associated with them, but much less abundant, may be picked up the silicified specimens, the angles of which are quite sharp, and showing no evidence of distant origin.

III.—The Silurian Rocks of Ireland and their Relation to the Old Red Sandstone.[2]

By G. H. Kinahan, M.R.I.A., etc.

A QUARTER of a century ago it was a disputed question whether the Old Red Sandstone was a separate formation or not. About that time, or a few years later, the subject engaged the attention of the Geological Section of the British Association.

When I joined the Geological Survey, Sir R. Griffith had mapped the older rocks in West Cork as of Silurian[3] age, while Jukes was inclined to class them as Old Red Sandstone. Plant-remains were found in rocks of the same series in the Killarney district by Du Noyer in the summer of 1855, and near Valencia by myself in

[1] Dr. Barton's Lectures on Natural Philosophy; Lecture 3, Metamorphoses, p. 51.
[2] Read Nov. 18th, 1878, before the Royal Geological Society of Ireland.
[3] In this paper Jukes' nomenclature is followed; the formations being called *Silurian* and *Cambro-Silurian* instead of Upper and Lower.

the following year. When the plants were pronounced by Salter to be of Carboniferous types,[1] Jukes considered the question to be finally settled; Griffith however said, "Wait till the Dingle district is examined, and you will find, that although the plants are of Carboniferous types, the rocks are Silurians."

When the Dingle peninsula was examined by Du Noyer, Foot, and Wynne, it was found that while there was a great unconformability between the lower and upper divisions of the strata called Old Red Sandstone, a complete conformability extended from the lower division downwards into fossiliferous Silurians, and from the upper division upwards into the Carboniferous Limestone and the Coal-measures. In the lower division, however, no fossils could be found,[2] and these strata were called "Dingle beds,"—a title which involved no assumption as to their age. To this lower division, according to both Griffith and Jukes, the above-mentioned rocks near Killarney, near Valencia, and in West Cork, belong

Subsequently these rocks were examined conjointly by Griffith, Murchison, and Jukes; and some of the party visited not only Cork and Kerry, but also Galway and Mayo. After this exploration Murchison was inclined to side with Griffith; but the plants were a stumbling-block. Furthermore the late Mr. John Kelly showed that the Dingle beds have the same stratigraphical position as the rocks mapped as Old Red Sandstone in the Curlew Mountains (cos. Sligo and Roscommon) and about Fintona (cos. Fermanagh and Tyrone); while the Curlew and Fintona rocks are lithologically similar to the Old Red Sandstone of the Commeragh, Galtee, and Knockmeeldown Mountains; the classification of the just-mentioned Cork and Kerry rocks therefore was left an open question until the rocks in Mayo, Roscommon, Sligo, Fermanagh, and Tyrone, suggested by Griffith to be of the same age as the Dingle beds, were examined.

The question remained in abeyance while the officers of the Geological Survey were examining the rocks of North-east Munster; until about 1864, when Foot declared that he suspected the rocks of the Curlew Mountains to be "Dingle Beds." The following year Jukes examined those rocks for himself, and subsequently announced his belief that the lower portion of the so-styled Old Red Sandstone, near Ballaghaderreen, to the west of the Curlews, was probably of the same age as the "Dingle Beds," as it seemed to lie conformably on similar fossiliferous Silurians, as previously stated by Kelly, while it was similarly capped unconformably by what all would regard as true Old Red Sandstone (Carboniferous). Still it was premature to say what its age might be until it and all the tracts mentioned by Griffith had been systematically examined.

At this time I began the work in West Galway and Mayo, and, after seven years' careful examination, I came to the conclusion that

[1] Mr. W. H. Baily has recently examined the plants from these localities in the Glengariff Grits.

[2] I have since learned from Mr. O'Kelly that fossils, like plant-stems, were subsequently found in the Dingle beds.

the oldest rocks there are Cambrians. These are partially covered, as it would seem conformably, by Cambro-Silurians. Resting unconformably on both of these are newer rocks, some of which years ago were proved by their fossils to be Silurians, but others for a time were considered to be Old Red Sandstone. All of these are capped unconformably by acknowledged (Carboniferous) Old Red Sandstone.

The rocks extending from Loughs Corrib and Mask by Maum to the Atlantic on the south of Killary Harbour had for years been known to be Silurians; but the rocks between Toormakeady on Lough Mask and Mweelrea north of the mouth of Killary Harbour, as also an isolated tract further north near Louisburgh, were at one time supposed, on account of their lithological character, to be Old Red Sandstone. Griffith, however, found Silurian fossils at Toormakeady, while subsequently I also found them in somewhat similar rocks in the Mweelrea Mountains. It was either during the exploration in which Griffith found the fossils at Toormakeady, or on a subsequent occasion, that he came to the conclusion that all were of Silurian age; the Louisburgh beds being the newest, and the representatives of a portion of the Dingle Beds.

To the northward of Toormakeady, in the neighbourhood of Croaghmoyle, there is a large tract of rocks, that Jukes, Symes, and myself were convinced to be of about the same age as the Toormakeady conglomerates, although it was marked on Griffith's map as Old Red Sandstone. This led me to seek for an explanation, and when my maps and sections were so far complete as to be intelligible, they were carefully examined and considered by Griffith. Subsequently I waited on him, by appointment, and in our conversation I learned that the marking of that district, as also of others, on his map, as Old Red Sandstone, was done in compliance rather with received opinions, than with his own conviction. That in the so-called "Old Red Formation" in Ireland, there was a marked unconformability,—part of it extending downwards conformably into the Silurian, and part of it upwards into the overlying Carboniferous rocks. That the rocks of West Cork, and adjoining portions of Kerry, of Dingle, of Toormakeady, of Mweelrea, of Louisburgh, of Croaghmoyle, of the Curlew and Fintona Mountains, he believed to be of nearly similar Silurian age. Those in the West Cork and Kerry, Dingle, Toormakeady, Mweelrea and Louisburgh, he had had time to examine properly, and had mapped them as Silurians, while the rest he had not so carefully examined. But in deference to Portlock's authority, and also because they were lithologically more or less similar to the Old Red Sandstone (Carboniferous) of the Knockmeeldown, the Galtee, and Commeragh Mountains, he left them as Old Red Sandstone. At the same time, he pointed out—"The Toormakeady Conglomerates are also similar, yet I found Silurian fossils in them."[1] In this conversation he also stated:

[1] Strictly, these fossils are not in the Conglomerates, but in the beds *below* them. As yet, in no place above the Toormakeady Conglomerates have fossils been found, except, perhaps, in the green tuff at Mount Partry—its position, however, is uncertain.

FIG. 1.

Irish Sections showing the Breaks in the rocks of the "Old Red Sandstone Formation."

(Scale 8000 feet = 1 inch.)

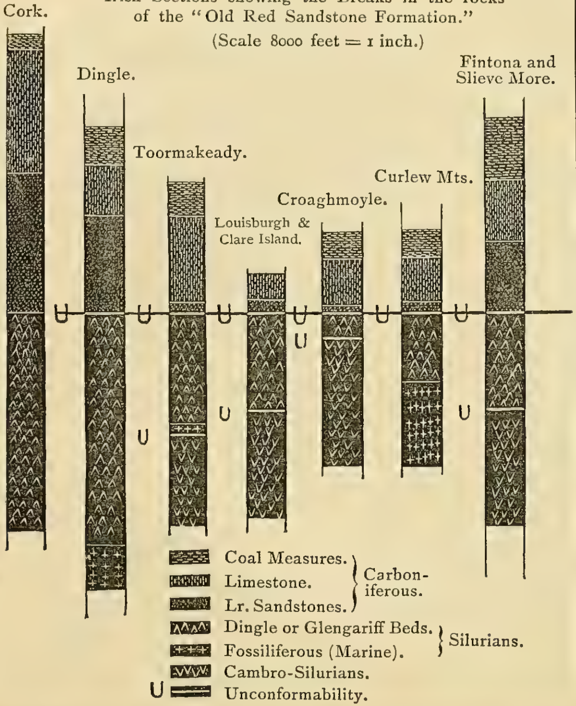
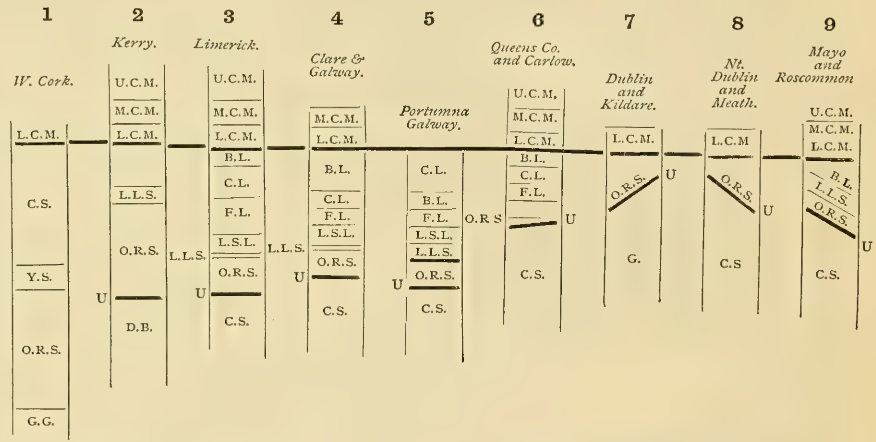


FIG. 2.



U.C.M. Upper Coal Measures.
M.C.M. Middle "
L.C.M. Lower "
B.L. Burren Limestone.
C.L. Calp "
F.L. Fenstella "
L.S.L. Lower Shaly Limestone.
L.L.S. " Limestone Shale and
O.S. Carboniferous Slate.
Y.S. Yellow Sandstone.
O.R.S. Old Red "

} Carboniferous.

G.G. Glengariff Grits. } Silurians.
D.B. Dingle Beds.
C.S. Cambro-Silurians.
G. Granite.
U. Unconformability.

NOTE.—In Sections 2, 7, and 8, the various limestones are irregularly interstratified.

"None of my work is guesswork; all my conclusions are from personal examination. I cannot now work out these rocks, and my map must remain as it is; the Geological Survey must complete the examination," or words to this effect.

After this interview, I paid more special attention to this subject,[1] and an epitome of my researches (except in respect to the equivalents of the Dingle Beds) appears in my recently-published "Manual of the Geology of Ireland." In that book I only hint at the age of the equivalent of the "Dingle beds," because at the time it was being written, more than a year ago, I was aware some of my colleagues were engaged working out the disputed rocks of the Curlew and Fintona Mountains, and I supposed they would have given attention to the question as to their age. It was not till the book was in print that I learned that the dispute had been ignored; although Mr. Berdoe-Wikinson's work proved that Jukes' and Foot's surmises in respect to the classification of the rocks of the Curlew Mountains were correct. Then, when I felt at liberty to express my opinion, it was too late to do so, except in the preface of the book.

The accompanying sections (Figs. 1 and 2) show the relations of the lower and upper divisions of the Old Red Sandstone to the Silurian and to the Carboniferous. In one table are given the sections of the Old Red Sandstone of Silurian age, and in the other most of the type sections of the true or Carboniferous Old Red Sandstone.

In the Ballycastle Coal-field, to the north-east of Antrim, Old Red Sandstone occurs interstratified in the Coal-bearing Calp. This is also the case near Draperstown, county Derry, where the Calp is very similar to that of Antrim, except that no workable coals have been found there; while in Armagh the Old Red Sandstone is interstratified with the Burren limestone. These three districts are grouped together, as in the rocks associated with the Old Red Sandstone are found fish-remains, more or less similar among themselves, and also to the fish-remains met with at Burdie House, Scotland.

To the north of the county of Dublin conglomerates occur close under the base of the Coal-measures, while in the rest of Dublin, Kildare, and Carlow, small patches of red conglomerate have been discovered, seemingly on different geological horizons. These appear to be only shore-beds, margining ancient lands; but in the county of Kilkenny, to the north-east of Thomastown, the Old Red Sandstone comes in as a distinct subdivision at the base of the Carboniferous Limestone formation, and increases in thickness as it is followed to the south-west. In this place, as also in the country between Knocktopher and Waterford, and in Slievenaman, the rocks are of the ordinary *Central Ireland type* (red and yellow shales, clay-rocks, sandstones, and conglomerates; the pebbles in the conglo-

[1] Foot and myself, in about 1864, wrote a paper to show that the Munster Old Red Sandstone was in part Silurian and in part Carboniferous; the paper, however, was not published, as Jukes considered it to be premature.

merates are usually small, and of white quartz, with some of red jasper); but south-west of the valley of the Suir, in the Commeragh, Galtee, and Knockmeeldown ranges, the type changes, the rocks being massive purplish conglomerates, interstratified with slaty grits or gritty slates. The pebbles in these conglomerates are often very large, while the maximum thickness of the subdivision seems to be considerable. The upper portion of the subdivision (called Upper Old Red Sandstone on the Geological Survey Maps, and Yellow Sandstone by Griffith), however, is still very like the Central Ireland type, except that the conglomerates are few or altogether absent. North of the Galtees, in Slieve Phelim, Kimalta, Slieve Arra, Slieve Bernagh, and Slieve Aughta (counties Tipperary, Limerick, Clare, and Galway), the rocks are for the most part of the Central Ireland type, although in places there are massive conglomerates; while in Slieve Bloom (King's and Queen's counties), the rocks are more like the Commeragh type.

South of the valley, between Dungarvan and Dingle Bay, there is a very complete change in all the rocks; from the base of the Coal-measures downwards, they assume peculiar types. The Cork type of the Old Red Sandstone has below massive, although generally cleaved, purplish and dark grey grits and slates (Old Red Sandstone); and above, when typical, yellow and greenish grits and shales, over variagated green, red, liver-coloured, and rarely purple slates (Upper Old Red or Yellow Sandstone).

The Old Red Sandstone is very constant in its characters, but the Yellow Sandstone changes considerably in the east and west direction, To the eastward, where it is overlaid by the Lower Limestone Shale and limestones, the Yellow Sandstone partakes in part of the Central Ireland Type, and contains more or less red beds; but towards the westward, where it is overlaid by the Carboniferous Slate, the red rocks die out, and the sandstones are replaced by grits. The greatest and most sudden change that I have observed is in the neighbourhood of the bay called Kenmare River. On the north and south sides of this bay, in the neighbourhoods of Sneem and Ardgroom, are tracts of Carboniferous Slate lying on Yellow Sandstone. Those to the eastward are cut off by faults with downthrows to the west, and further east, at Kenmare, are limestones and the Lower Limestone Shale resting on bright red rocks, the latter lying conformably on the Old Red Sandstone. These bright red rocks are evidently on the same geological horizon as the Yellow Sandstone to the westward of them, although so totally different. The Old Red Sandstone extends conformably downwards into the Glengariff Grits, which, as previously stated, are considered both by Griffith and Jukes to be the equivalents of the Dingle Beds, and by the first to belong to the Silurian formation.

On the north of Dingle Bay the Old Red Sandstone belonging to the Carboniferous is nearly similar to that in Cork, but in places it contains conglomerates. It has a great thickness (over 5000 feet), and its upper portion is somewhat like the Yellow Sandstone of Cork, but contains more red beds. Farther east, in the county Limerick, this Old Red Sandstone is like the Yellow Sandstone of North Kerry, but it is apparently much thinner; while still farther east are the already-mentioned rocks of Slieve Phelim. In Connaught, except in Slieve Aughta, south-east Galway, also in the north-west of Leinster, the Old Red Sandstone is evidently a shore formation at different horizons in the Limestones; but in Fermanagh and Tyrone it seems to be at the base of the Carboniferous. The rocks are more or less similar to the Central Ireland type.

We have now given a short résumé of the Old Red Sandstone adjuncts of the Carboniferous, and may now proceed to explain the sections of the Silurian portion of the Old Red Sandstone. We have mentioned that the Dingle Beds on the north of Dingle Bay, which are capped unconformably by Carboniferous Old Red Sandstone, are considered by such competent authorities as both Griffith and Jukes to be the equivalents of the Glengariff Grits, which in the Killarney district and in West Cork extend conformably upwards into the Carboniferous rocks. The authority of these geologists is scarcely to be questioned; we therefore take it as proved, and proceed to the next section.

At Toormakeady, county Mayo, are conglomerates lithologically somewhat similar to the Commeragh Old Red Conglomerates, but in the beds at the base of the Toormakeady Conglomerates are Silurian fossils; and further westward, in the very similar rocks of the Mweelrea Mountains, Silurian fossils also occur. On these rocks the Carboniferous strata lie unconformably.

North of the Mweelrea rocks are the Louisburgh Beds. In them no typical Silurian fossils have been found, but lithologically they are similar, in part to the Mweelrea pebbly grits, and in part to the Salrock slates; the latter being the highest beds in the Galway Silurians.

To the north of the Toormakeady Conglomerates, east and north-east of Clew Bay, are the Croaghmoyle Conglomerates. No typical fossil have been found in them, but lithologically they are similar to the Toormakeady rocks, also to those to the north-east, in the Curlew Mountains; while they are capped unconformably by the Carboniferous rocks.

The Curlew Mountain rocks are lithologically more or less similar to those already mentioned. They extend downwards conformably into Silurians, having fossils similar to those in the Silurians that, in the county Kerry, underlie the Dingle beds; while upwards, similar to the Kerry rocks, they are cut off and are capped unconformably by the Carboniferous beds.

The rocks of the Fintona district are lithologically similar to those of the Curlew Mountains, and are also capped unconformably by the Carboniferous series. Of these Portlock states that in one place they seem to lie conformably on the Cambro-Silurians. Griffith, however, in conversation, stated that he suspected there was a sequence of rocks somewhat similar to that near Ballaghaderreen, and that Silurian fossils occurred in them similar to those at Toormakeady. This supposition rests solely upon information which I have not had an opportunity of working out.

Let it be clearly understood that, in no place in the above-discussed rocks—of Cork, Dingle, Toormakeady, Louisburgh, Croaghmoyle, Curlew Mountains, or the Fintona districts, have fossils been found to prove distinctly that they are of Silurian age. The only indirect evidence of that kind which can be produced being the fossils in the Mweelrea beds; which may perhaps be on the same geological horizon as the unfossiliferous rocks of Toormakeady, Louisburgh, Croaghmoyle, and the Curlew and Fintona districts; while on the other hand there are plants of Carboniferous types found in the Dingle and Glengariff beds. Therefore it is no doubt possible, that (if there is such a distinct formation as the Old Red Sandstone) these rocks may belong to it. It is evident, however, that they all are of one and the same age,[1] and it is the height of absurdity to class the Dingle beds,[2] with plants of a Carboniferous type, among the Silurians, while the Curlew and Fintona rocks are put in a separate formation and called Old Red Sandstone. That the Old Red Sandstone formation is the *Sick Man* of Geology seems proved; as its supporters are reduced to suggesting the existence of extraordinary unconformabilities to allow of its existence; or to distorting the different rock sections and representing the rocks, not as they really are, but as they ought to be in the opinion of these different observers. The title of Old Red Sandstone to be ranked as a distinct formation seems to depend on the meaning given to the expression a *Geological Formation.* The generally accepted meaning seems to be—a series of strata with a more or less well-defined beginning and ending, its distinctness being marked palæontologically and (almost always) stratigraphically;—these characteristics the Old Red Sandstone does not seem to possess.

In South-west Ireland, indeed, there is a vast continuous unbroken series of reddish, purplish, and greenish arenaceous and argillaceous rocks, over 20,000 feet thick, that extend upward from the typical marine Silurians of Dingle to the typical marine Carboniferous of Cork. These must represent the time during which the Old Red Sandstone accumulated, in Ireland or elsewhere. In this series, except in the upper 1000 or 2000 feet, (Yellow Sandstone) fossils occur at rare intervals, and are principally plants allied to Carboniferous types. In the Yellow Sandstone terrestrial fossils are much more common; while in the lower beds of the overlying Carboniferous Slate, strata containing terrestrial and marine fossils alternate with each other.[3] In South-west Ireland the rocks,

[1] In the Dingle Silurians, in the Toormakeady conglomerates, in the Mweelrea beds, in the Curlew rocks, and in the Fintona rocks, there are peculiar and characteristic felstones and traps that seem to be of the same age.

[2] As the Continental and American geologists have found plants like Carboniferous in the Silurians, this evidence against the Silurian age of the Dingle and Glengariff beds may be considered in part at least as done away with.

[3] It has been suggested that there is an unconformable overlap of the Carboniferous Slate on the Yellow Sandstone. This, however, is perfectly impossible, for such an overlap could not exist without, in places, adding rapidly to the thickness of the Carboniferous Slate, which nowhere happens; furthermore, the Carboniferous Slate everywhere graduates downwards into the Yellow Sandstone, and the latter into the Old Red of the Cork type.

including the Yellow Sandstone, the Old Red, and the Glengariff Grits, might possibly be called a formation; if it were not that north of Dingle Bay there is a great break in the sequence, the upper 5000 or 6000 feet, only, extending continuously into the Carboniferous rocks. Stratigraphically and palæontologically this upper portion belongs to the Carboniferous formation; while the lower portion, over 10,000 feet in thickness, stratigraphically belongs to the Silurians, but palæontologically to the Carboniferous.

It has been suggested that the Old Red Sandstone (Carboniferous) of the Dingle promontory (2, Fig. 2) cannot be the same as the Old Red Sandstone (Carboniferous) of West Cork (1, Fig. 2), as such a change in their positions could not take place in so small a distance as the width of Dingle Bay. This suggestion, however, is not borne out by facts, as extending along Dingle Bay there is a great fault with a downthrow to the northward, which, to the eastward of the bay, brings down the Coal-measures against the Old Red of the Cork type, and cuts out a thickness of strata more than sufficient to account for a greater change. Elsewhere in Ireland, as shown in the sections (Fig. 2), rocks having the Old Red Sandstone characteristics, and, like it, graduating into the Lower Limestone Shale, occur on different geological horizons.[1]

Note in Press.—Since this paper was read, Prof. Hull, in the Geological Magazine, November 1st, 1878, published "A Possible Explanation of the North Devon Section." Unfortunately for the suggestions contained in it, there are various errors in reference to the Irish rocks.

All the Irish geologists who have studied the Dingle and Glengariff Grits came to one conclusion about them, that is, that they belong to one group, and Prof. Hull has now arrived at the same conclusion. If this is allowed, we have a vast *continuous* series of rocks which represents all the time intervening between the accumulation of the typical Silurian of Dingle and the typical Carboniferous of Cork. This necessitates some portion of this series of rocks being the equivalent of the Old Red Sandstone or the Devonian rocks. Those that are acquainted with the Old Red Sandstone (Griffith and Jukes) in the country south of Dingle Bay are aware that it contains fossil plants said by Baily to be also found at Kiltorcan, county Kilkenny, while farther southward, near Toe Head, county Cork, and in the county Waterford, the Kiltorcan fossils are well represented. The rocks containing these fossils lie conformably on the Glengariff Grits, while the latter also contain plants said by Baily to be of the same type as some of the fossils of Kiltorcan. Thus these Old Red Rocks, also the Glengariff Grits, according to Prof. Hull's reasoning, should be of the same age as the Kiltorcan beds, and consequently Old Red Sandstone. Yet this authority states that the Glengariff Grits are certainly Silurians.

An unconformability in the Cork rocks between the Carboniferous

[1] Its uncertain position induced the Rev. Dr. Haughton, in the year 1863, to designate it a "Phantom formation."—Journal Geol. Soc. Dublin, 1863.

Slate and the Glengariff Grits is an impossibility, on account of the universal parallelism between the strike of the beds in the first with those in the underlying Yellow Sandstone, Old Red Sandstone, and Glengariff Grits. The question of the age of the Glengariff and Dingle Beds, so far as their relative positions are concerned, remains nearly as undecided as in Jukes's time. Jukes found that stratigraphically these rocks were allied to the Silurians, but Salter insisted that the fossils were Carboniferous, and that the rocks should be similarly classed; at the present time Baily reiterates Salter's opinion.

Are the Dingle or Glengariff Beds Silurian or Old Red Sandstone? —The answer to this question depends on the relative values of,—stratigraphical position and fossil evidence. If the first is most important, then the rocks belong to the Silurian; but if the second, then they are of Old Red Sandstone age, a group of rocks that form passage-beds from the Silurian into the Carboniferous. It seems remarkable that Prof. Hull should class the Dingle and Glengariff Beds as Silurians, while he has mapped the rocks of the Curlew Mountains, which are stratigraphically similar, as Old Red Sandstone.

It is unnecessary to enter into Devonian geology further than to point out that Jukes' fault has not been disproved, while the Irish geologists who have been in Devon believe in its existence; also the fossil evidence, so much relied on, seems not to be of much geological value, inasmuch as the species have been collected without that care and precision which can alone render them of use in marking horizons. The localities assigned to the specimens, in the collections chiefly relied upon, are such as Torquay, Chudleigh, etc.; where two, if not more, distinct groups of rocks are developed.

IV.—Historical Geology of Cornwall.

By W. A. E. Ussher, F.G.S.

(*Continued from the January Number, p.* 36.)

(PLATE III.)

Part 4.—*St. Michael's Mount.*

THE best description of St. Michael's Mount, as it now exists, that I can find, is by Mr. Wm. Pengelly, F.R.S.,[1] as follows: "The Mount is an isolated mass of granite measuring about five furlongs in perimeter at its base. At high-water it plunges abruptly into the sea, except on the northern or landward side, where the granite comes in contact with the slate, into which it sends veins and dykes, as may be well seen on each side of the harbour. Here there is a small plain occupied by a village, adjacent to which is the harbour, built in 1726-7, and, as Mr. Johns, the harbour-master, has been good enough to write me, capable of receiving ships of 500 tons burthen." Its situation is described as follows: "The distance between the nearest point of Marazion Cliff and spring-tide high-water mark on the Mount is 1680 feet. A tidal isthmus (Hogus) of highly inclined Devonian slate and associated rocks, in most cases covered with a

[1] Journ. Roy. Inst. Corn. for 1873, p. 12.

thin layer of gravel or sand, is at spring-tide high-water, in still weather, 12 feet below; and at low-water 6 feet above the sea-level. This ridge is dry in fine weather from four to five hours every tide, but occasionally during storms and neap tides it is not passable for two or three days."

"St. Michael's Mount[1] was named in Cornish, as Carew informs us 'Caraclowse in Cowse, in English, the hoare rock in the wood: which now is at every flood encompassed by the sea, and yet at some low ebbs, roots of mighty trees are descried in the sands about it.' . . . . . Florence of Worcester expressly asserts that it was formerly five or six miles from the sea and enclosed with a very thick wood; and therefore called in British, Carreg lug en Kug, 'Le Hore Rok in the wodd.'"

The above is said to have been corrected by Florence of Worcester in a letter to William of Worcester, 1478.[2]

Mr. Peacock[3] thinks that we need not go back further than the time of the Domesday Book for the origin of the Cornish name of St. Michael's Mount, "Carreg coedh yn clos," *i.e.* "Rock of the wood in the enclosure," as William Camden (1550-1623) "proves that the Cornish language had not become quite extinct even so lately as his time."

"Dr. Gibson,[4] the editor of Camden's Britannia, says that St. Michael's Mount is called Careg Cowse in Clowse. Careg is, doubtless, the origin of the English word crag; and cowse is said to mean cana, white; and clowse obviously means a close or enclosure."

"Mr. Metivier says that St. Michael's Mount was 'Carreg Coed yn Clôs,' rock of the wood in the enclosure."

Mr. Peacock[5] says that "the earliest period at which the Saxon name Mychel Stop, or Michael's Step, could have been given to the Mount, was after the landing of Hengist and Horsa in 449."

The Mount received its present name in 1085, from the Monastery of St. Michael, of which it then became an appanage; before that time it was called Dinsol.[6]

"In Milner's Gallery of Nature, p. 387, it is stated that in the time of Edward the Confessor, 1044, the rock of St. Michael's Mount was the site of a monastery described as being near the sea, 'juxta mare' (interpreted by Barham, 'by the sea')."

"The ancient designation," says Mr. Pengelly, "betokens a change in the geography of the district—a change, not only within the human period, but since Cornwall was occupied by a people who spoke the language which was tardily supplanted by the Anglo-Saxon."

Mr. Pengelly refers the name "Hogus," now applied to the rocky ledge between Marazion and the Mount, to an old Scandinavian derivation, meaning "a rock in or near a wood adjacent to water, and used for sacrificial purposes."

Mr. Peacock[7] takes exception to this determination on the ground that Hogus (in Guernsey hougue, French hogue, neo-Latin hoga)

[1] T. R. G. S. Corn., vol. ii. p. 134.
[2] Pengelly on Submerged Forests in Torbay. [3] Peacock, p. 110.
[4] Ibid. p. 89. [5] p. 111. [6] Ibid. p. 112. [7] Peacock, p. 107.

sometimes denotes a quarriable knoll, of which he gives examples. From this Mr. Peacock infers that the term Hogus only carries us to the middle ages, and not to the time of Diodorus.

Mr. Peacock[1] quotes Diodorus Siculus (about 44 B.C.) as follows: "They who inhabit the promontory Belerium are exceedingly hospitable, and on account of the merchants being their guests are civilized by custom in their mode of life. They procure the tin by ingeniously working the earth producing it, which, being rocky, has earthy veins, in which working a passage and melting (the ore) they extract [the tin]. Forging it into masses like Astragals, they carry it into an Island situate before Britain, called Ictis. For the middle space being dried by the ebb they carry the tin into this (island) in abundance in carts. (But a certain peculiar thing happens concerning the neighbouring islands lying in the middle (*μεταξυ*) between Europe and Britain, for at full sea they appear to be islands, but by the reciprocation of the ebb of the sea, and a large space being dried, they appear peninsulas.) Hence the merchants buy [the tin] from the inhabitants and export it into Gaul."

Taking *μεταξυ* to mean "in the middle," Mr. Peacock considers that the Northern Channel Islands were alluded to in the above passages, being of opinion that the Northern Channel Islands were then only insulated at high-water, and that they are called neighbouring islands to distinguish them from the more remote islands in the Bay of Biscay.

Mr. Pengelly[2] observes that, according to Leland, St. Michael's Mount in 1533 was no larger than at present; that William of Worcester's estimation of its distance from the mainland differs but little from its present site: that "Bishop Lacy's encouragement to the Faithful in 1425 to complete a causeway between Marazion and the Mount, for the protection of life and shipping, denotes that the exposure was as great as in our day; and as the Confessor's Charter in 1044 describes the Mount as 'juxta mare,'[3] next or by the sea, it may be safely concluded that the insulation of the Mount had taken place more than eight centuries ago."

After a passing allusion to other competitors for the Ictis of Diodorus, he says, "It is perhaps worthy of remark, that those who have studied the Geology of Cornwall, espoused the cause of the Mount; while those who fail to do so, appear to have come to the question with their minds imbued with a belief in William of Worcester's statement, that there were 140 parish churches submerged between the Mount and Scilly, and accordingly hold that the submergence took place not only since the time of Diodorus, but since the introduction of the parochial system into Cornwall."

Mr. Pengelly quotes Sir George Cornewall Lewis (An Historical Survey of the Astronomy of the Ancients) as follows: "Timæus mentions an island of Mictis within six days' sail of Britain which produced tin, and to which the natives of Britain sailed in coracles." He regarded Mictis and Ictis as variations of Vectis.

[1] Peacock, p. 86. [2] Journ. Roy. Inst. Corn. for 1873, p. 181.

[3] "Sanctum Michaelum qui est juxta mare."

From Mr. Pengelly's statement that the Mount 1900 years ago possessed a harbour, Mr. Peacock dissents on the ground that "if the coast had remained unaltered ever since Diodorus's time, the Roman tin-transporting ships need not by any means have been confined to St. Michael's Mount as a harbour, because, as the Rev. W. Borlase[1] well observes, Guavas Lake is the principal anchoring place." Whence he considers that the chief export of tin could not have taken place from St. Michael's Mount, and does not favour the belief in its identification as the Ictis of Diodorus. He says further:[2] "The ancient block of tin which was dredged up about 1823 in Falmouth Harbour (Lyell's Principles of Geology, 1867, p. 451), if we suppose it to have been dropped during its transit to the Isle of Ictis, would seem to place Ictis opposite Falmouth harbour, and therefore twenty miles east of St. Michael's Mount."

Mr. Pengelly, in a lecture at the Royal Institution,[3] says, "The Mount is by no means a solitary rock of its kind. Within seventy miles east of it there are certainly four that actually are or probably were, within the last 1900 years, precisely similar though slightly larger islands—Looe Island, St. Nicholas Island, the Mewstone, and Borough Island."

Mr. Peacock cherishes the idea that the Mounts Bay forest was submerged in the historic period, and is sufficient confirmation of the "tradition of these parts that St. Michael's Mount, now enclosed half a mile with the sea, when the tide is in, stood formerly in a wood."

He quotes the following note from Carew (1602):[4] "Tradition tells us that in former ages the Mount was part of the insular continent in Britain, and disjoined from it by an inundation or encroachment of the sea, some earthquake or terrestrial concussion."

"If," says Mr. Peacock,[5] "the storm of 1099 and Dr. Borlase's submersion[6] in the ninth century be true, St. Michael's Mount cannot have been the ancient isle of Ictis, because must we not suppose that the Mount only became an island at one of these submersions." Mr. Peacock strengthens his position by the following quotation[7] from page 2 of the Domesday Book: "The land of Michael . . . there are two hides which never paid the Danish tax (nunquam geldaverunt). The land is eight caracutes."

The hide is generally supposed to be equal to 120 acres.[8] Sir. H. Ellis says that the measure of a hide varied in different places at different times. "The carucate was as much arable land as could be managed with one plough and the beasts belonging thereto in a year; having meadow, pasture, and houses for the householders and cattle belonging to it."

Taking the smallest estimate of a "hide" from the five different measures of it in the reigns of Richard I., Edward I., and Edward II.,

[1] Phil. Trans. vol. 48. [2] Peacock, p. 118.
[3] Quoted by Peacock, p. 139. [4] p. 140. [5] Peacock, p. 88.
[6] Dr. Borlase was inclined to refer the submersion of St. Michael's Wood to the inundation of the year 830, mentioned in Irish Annals. Mr. Whitaker ascribed it to that mentioned by the Saxon Chronicle and Florence of Worcester as occurring in 1099. *Vide* T. R. G. S. Corn., vol. ii. p. 139.
[7] Ib. p. 137. [8] Ib. p. 113.

which vary from 60 to 180 acres, Mr. Peacock says that eight carucates would have amounted to 490 acres, whilst[1] the present dimensions of the Mount, measured from the Ordnance Map, "are found to average 22 × 14 chains; the area therefore is 30·8 acres;[2] and it is quite clear that, so far from there being eight carucates of arable land, there can hardly be a single acre capable of being ploughed, because the ground is too steep and rocky."

Mr. Peacock[3] believes that at the date of this description in the Domesday Book (in the year 1086), St. Michael's Mount was not an island, for the following reasons: Firstly, because neither the Domesday Book nor the Saxon name Michael Stop give any reason for such a conclusion. Secondly, because it is the custom in the Domesday Book, "when a place is an island, to call it so." Of this he gives examples. Thirdly, on account of its then containing at least eight times as much land as at present.

Of the several remaining competitors for the Ictis of Diodorus, Mr. Peacock disposes as follows:—

As the Scilly Isles do not lie between Europe and Britain, and as there is a 43-fathom sounding between them and the Land's End, none of them would answer to the description of Ictis.

As to the Isle of Portland or the Isle of Wight, so accurate an observer as Diodorus would not have failed in distinguishing their position definitely as "near the south coast of Britain, nor are there any grounds for the supposition that the relations of either locality to the mainland were different in Diodorus's time from the present."

With respect to the claims of Mont St. Michel, he considers that the space between it and the Continent was the Forest of Scisy and not sea until seven centuries and a half after Diodorus's time.

As alternatives, Mr. Peacock proposes the Wolf Rock (which would be opposite Britain if a westerly and north-westerly extension of the Cornish coast be conceded); the Seven Stones; or some island now totally lost. He considers, however, that the identification of Ictis is "both impossible and unimportant."

Mr. Claypole[4] gives an estimate of the uniform rate of depression of Mounts Bay on assuming the identity of St. Michael's Mount with the Ictis of Diodorus and the Ocrinum of Ptolemy. He says: "It must then have been an island as now at high-water only. In the time of Diodorus the isthmus must have been below high-water mark. So depression must be restricted to limits allowing the isthmus to have been below the upper limit of 20-foot tide, 1800 years ago, and above its lower limit now: so that it would not have exceeded 6 feet, therefore the rate of depression would be 4 inches per century, which would be 6 feet in 12,600 years."

Mr. Pengelly,[5] commenting on the evidence furnished by the caverns of Devon, gives the following general note, which may not be out of place here: "In order to obtain the whole, we must add to this part the time represented by the lodgement of the Blue

[1] Peacock, p. 135. [2] Ib. p. 114. [3] Ib. pp. 112, 113.
[4] Proc. Brist. Nat. Soc. 1870, vol. v. p. 35.
[5] Journ. Royal Instit. Corn. for 1873.

Forest Clay of Devon on the tin ground of Cornwall; to this again must be added the period in which the forests grew; to this a further addition must be made of the time during which the entire country was carried down at least 70 feet vertically by a subsidence so slow and tranquil and uniform that it nowhere throughout the area of Western Europe and the British Islands disturbed the horizontality of the old forest soil; and finally we must also add the time which has elapsed since—a time which of itself, thanks to the description of St. Michael's Mount by Diodorus Siculus, we know certainly exceeded 2000 years, and which the volume of the stratified deposits overlying the forests, as well as the amplitude of the existing foreshore, warrants our believing exceeded it by a very large amount."

Conclusion.—If the word Cassiterides, in the writings of Strabo, Posidonius, and Diodorus, refers to the Scilly Isles, and if they have also been mentioned by Dionysius Alexandrinus under the name of Hesperides, the quotations from these authors would imply the following consequences.

First,—That tin must have been obtained in the Scilly Isles as they then existed.

Secondly,—That, as no productive tin veins or signs of old workings are found on these islands, such workings must have been carried on in districts now submerged, at a time when the number of the islands (allowing a considerable margin on the score of insignificance in Strabo's account) was much less than at present, and when the flats between the islands of Tresco, St. Mary, and St. Martin (as may reasonably be inferred from Dr. Borlase's description), were dry land at high-water and above the level of spring-tides.

Thirdly,—That the Channel Islands were not insulated in Diodorus' time; for, if they were, he would hardly have alluded to the Scilly Isles as nearest to Iberia. This accords with Mr. Peacock's views as to their more recent insulation.

Fourthly,—From Alexandrinus' account, must we not suppose that the inhabitants of the islands were a colony from Spain in his time, and either supplanted the original inhabitants alluded to by Dr. Borlase, or were themselves succeeded by a British race, addicted to Druidic rites?

Notwithstanding, I am inclined to think that the word "Cassiterides" was indiscriminately used for the Scilly Isles and Land's End District,[1] owing to the imperfect navigation of those early days of naval commerce.

Diodorus's description of the inhabitants and mineral wealth of Belerium would apply rather to a district of that name than to an individual promontory, and it does not seem improbable that the name of one of its most important headlands should be indiscriminately applied to the whole stanniferous district of the Land's End. If, as Mr. Peacock supposes, the Northern Channel Islands are spoken of by Diodorus as neighbouring islands with reference to Ictis, one can scarcely agree with him in disposing of the claims of

[1] T. R. G. S. Corn. vol. vii. p. 153.

the Isle of Wight to the appellation of Ictis on the ground of the accuracy of that historian's descriptions. If the name Vectis[1] applied exclusively to the Isle of Wight, Pliny's mention of it as lying between Ireland and Britain would prevent one from putting too much faith in the latitudes and longitudes of ancient geographers. (Vide Note B.)

To revert to more recent records. As the description of St. Michael's Mount in the Domesday Book is so indefinite, and, from the nature of the record, rather applicable to the lands belonging thereto than to the geographical position of the Mount itself, there appears to be little reason why the eight carucates mentioned in the passage should not be regarded as arable lands on the adjacent mainland belonging to the monastery. The submergence of the Mounts Bay forest seems to have occurred considerably anterior to any inundation on record, for the following reasons.

First,—Mr. Carne[2] mentions the extension of the old forest ground seaward, traced to a depth of from twenty to thirty feet below spring-tide level.

Secondly,—There is every reason to conclude, with Mr. Carne, that the forest bed met with in a pit at Huel Darlington mine, under 12 feet of marine sediment, four feet of peat, and eight feet of river wash, is continuous with the forest bed on the beach.

Thirdly,—Whilst the entombment of the forests in marine sediments indicates subsiding movements, the peat and overlying gravel in Marazion Marsh, and the present positions of rock platforms slightly higher than spring-tide at high-water, and of estuarine deposits, seem to point to a slight subsequent elevation, not yet counteracted. The changes which took place after the submersion of the old forest ground can hardly have been comprised in eight centuries, and were more probably operating during a period of more than 2000 years. A belief in the pre-historic[3] submergence of the Mounts Bay forest is by no means contrary to the identification of St. Michael's Mount with the Ictis of Diodorus; for, although the land may have been at a slightly lower level in the time of Diodorus than at present, the rapid disappearance of thirty-six acres of pasturage from the West Green sand-banks[4] since Charles the Second's time, mentioned by Dr. Boase (T.R.G.S. Corn. vol. iii. p. 131), leaves one free to infer that prior to that time the bank was of still greater extent, so that its eastward portion may have facilitated the passage to the Mount by affording a ridge or causeway of sand covering the rocky isthmus and passable in most conditions of the tides. The Wolf Rock and the Seven Stones can scarcely be regarded as possible competitors for the Ictis of Diodorus; their admission would entail a subsidence of at least 200 feet within 2000 years, as the former is seven miles to the south-west of Guethenbras Point (Land's End district), with

[1] (Peacock, p. 183.) Pliny, Nat. Hist. lib. iv. § 30: "Sunt autem xl Orcades modicis inter se discretæ spatiis. Septem Acmodæ, et xxx Hebrides; et inter Hiberniam ac Britanniam, Mona, Monapia, Ricina, Vectis," etc.

[2] T. R. G. S. Corn. vol. vi. p. 230, etc.

[3] As far as Britain is concerned.

[4] The banks are now only two or three acres in extent.

intervening depths of from twenty-one to thirty-eight fathoms; and the latter are fourteen miles west from the Land's End, with depths of thirty-two to forty fathoms between them and the Longships. St. Michael's Mount appears better to accord with the description of Diodorus than any other island on the Cornish coast, on account of, firstly, its vicinity to tin-producing districts; secondly, the facility with which carts laden with the ore could have reached it, either on the supposition of an elevation of a few feet, or allowing the extension of the sand-bank from the mainland or the existence of a sand spit concealing the isthmus.

APPENDIX.

Note A.—A rock near the Land's End bears the name of "the Armed Knight." Though this appellation may have been bestowed on it through a fancied resemblance in outline, the existence of the tradition respecting Trevelyan's adventure appears to furnish a more likely reason for the name.

Note B.—In Speed's Map of Cornwall, 1610, no dependence can be placed upon the latitudes, as may be seen by placing a tracing of a reduced Ordnance Map of the same scale (about 1 inch to 4 miles) over it, when the Land's End district will be found to occupy entirely different positions scarcely overlapping in any place, and the shape of the Lizard district to be quite dissimilar.

Another map without date, but probably as old as Speed's, was shown to me by Mr. Parfitt, of the Devon and Exeter Literary Institute; the same discrepancies were visible in it.

Now when we find discrepancies of latitude equal to 10′, and the shapes of promontories entirely misrepresented in maps of their own country produced by geographers 300 years ago, how can we expect to find even as great accuracy in the geographical descriptions of Roman or Greek historians, more especially when relating to coasts with which they must at best have been very slightly acquainted?

NOTICES OF MEMOIRS.

On the Extinct Wingless Birds of New Zealand. By Richard Owen, C.B., F.R.S., etc. (London: John Van Voorst, 1, Paternoster Row.)

Baron Cuvier, in the "Avertissement" to the First Edition of the 'Recherches sur les Ossemens Fossiles des Quadrupèdes,'[1] assigns as a reason for reprinting, with additional matter, his "morceaux détachés dans les 'Archives du Muséum d'Histoire Naturelle,'" the facility which would thereby be afforded to students of fossil remains in their comparisons with the text and plates of such Work.

A like motive has led the Author to collect his detached Memoirs on the Fossil Bones of the Birds of New Zealand, which have appeared in successive Parts of the 'Transactions of the Zoological Society of London' since the year 1838, and to similarly combine them with additional matter and general remarks in the two volumes now issued.

His purpose, long entertained, was strengthened by the appearance and favourable reception of an excellent and comprehensive Work on the existing Birds of New Zealand,[2] to which the present Volumes may be deemed complementary.

[1] 4to. 3 vols., 1812.

[2] 'A History of the Birds of New Zealand,' by Walter Lowry Buller, Sc.D., F.L.S., etc. 4to. (London, John Van Voorst, 1872.)

They comprise an Introductory Notice of the circumstances which led to the discovery and restoration of the extinct Avifauna of New Zealand. The descriptions are accompanied by Illustrations of the natural size of the fossils, and reduced views of the restored skeletons on which the several genera and species have been founded. The whole is preceded by an illustrated Anatomy of the existing wingless bird (*Apteryx australis*) which is the nearest ally of the extinct *Dinornis*; and is followed by notices of the food, footprints, nests, and eggs of the Moas, the Maori traditions relating to those gigantic birds, the causes and probable period of their extirpation, and a speculation on the conditions influencing the atrophy of the wings in flightless birds.

The latter topic has led the Author to append Supplementary Memoirs on the Dodo, Solitaire, Great Auk, and some evidences of gigantic extinct Birds of Australia and Great Britain.

His advanced age has led him to issue the present Work entire, in preference to a publication in Parts. It consists of a Quarto Volume of Text (512 pp.), and a similar Volume of 130 Plates, several of which, from the size of their subjects, are in folio. With the Text are intercalated Woodcuts.[1] Dr. Hector's Geological Map of New Zealand, giving the localities of the discovered fossils, is annexed.

REVIEWS.

I.—The Physical System of the Universe. An Outline of Physiography. By Sydney B. J. Skertchly, F.G.S. 8vo., pp. 385. (London, Daldy, Isbister & Co., 1878.)

SINCE the Science and Art Department determined to hold an Examination in Physiography we have been presented with various text-books on the subject. Professor Huxley, the Rev. Alexander Mackay, Professor Ansted, and more recently Mr. Skertchly, have come into the field; while in late numbers of "Good Words" Mr. Norman Lockyer has contributed a series of physiographical sketches on "The Earth's Place in Nature."

This subject—which, at South Kensington, seems to have supplanted Physical Geography, ought, however, in no sense to interfere with it. Physical Geography deals with the configuration of the earth's surface, and with the distribution of its various forms of life; it is, in fact, the geology of the present day, and must always retain more or less of an individuality so far as any study can do so.

Physiography, on the other hand, endeavours to knit together the sum and substance of all that is known of the physical history of the universe—it is, in fact, a Cosmogony—though its chief aim is to develope the intimate connexion between all sciences, and to illustrate the Unity of Creation.

It is only within the past few years that Physiography has assumed its present comprehensiveness. The term has not unfrequently been in use to designate the physical aspect or contour of any tract on the earth's surface. Nor has the connexion of various sciences been

[1] The price of the Work is £6 6*s*.

lost sight of, for as early as 1849 a little work entitled "The Unity of Nature," by John Warren Howell (edited by Charles Pooley), was published; a work whose object was to show the relation of the sciences one to another. But recent spectroscopic observations have especially led to the conclusion that all the heavenly bodies "are but parts of one stupendous whole."

In the work now before us, Mr. Skertchly gives us an outline of physiography, embracing all the latest work in astronomy and physical science which bears upon the history of the universe. It is, we must premise, a work which contains a good deal of hard reading, and perhaps too many technical terms to please an ordinary reader. In the introductory chapter the author briefly sketches the plan of his work, and shows that the past and present state of the globe are the result of the action of heat upon solid, liquid, and gaseous matter. Chapter 2 deals with Matter and Motion, and it is pointed out that the earth is not an isolated fragment in space, but part of one great machine. Chapter 3 treats of Light and its Revelations, and it is shown that the sun, stars, etc., contain the same elements known to us on earth. Chapter 4 is devoted to the Sidereal System —a term applied to the whole of the visible universe, with its hosts of stars, nebulæ, etc., and it is pointed out that not only is it composed of the same kind of matter, but this is acted upon by the same laws as terrestrial matter. In Chapters 5, 6, and 7, the Solar System is treated; the motions, reactions, and influences of the bodies are dwelt upon, also the origin and movements of meteors and comets. Chapter 8 is devoted to the Sun, and all that is known of it—the influence of the cycle of its spots on terrestrial magnetism, temperature, rainfall, and other phenomena. Chapter 9 deals with the Earth's Internal Heat, in which it is concluded that the interior is probably metallic; that, as a whole, the earth is very rigid, and cannot be molten in the interior; that it contains great cavernous spaces more or less full of liquid rock; and that volcanic action has been far more extensive than it is at present. The effects of Internal Heat and influence on the production of faults and contortions, upheavals and depressions, and in the sketching out of the broad features of the continents are noticed in Chapter 10. The effects of the Earth's External Heat are pointed out in Chapter 11, where various climatic conditions are shown to result from Solar Heat. Chapter 12 continues this subject in its bearing on Earth Sculpture, where the influence of Subaërial Denudation is noted as the most prominent. In Chapter 13 the subject of Climate is again dealt with, also the causes of great variations in past periods. The conclusions being that cold and warm periods alternated in comparatively rapid succession during the Glacial period; and that they are due to the indirect results of a high excentricity, combined with the position of the solstitial points in aphelion and perihelion. Chapter 14 deals briefly with Life, and it is shown how dependent the forms and their distribution are upon climatic change. The concluding chapter discusses the Nebular Hypothesis, which, while it is stated to be the natural explanation of the Solar system, yet is not supported by what is known of existing nebulæ; they do not contain the spectra of all the known elements, and hence it might be inferred that none of them could condense into a system like ours. To this, Mr. Skertchly replies that, "It may be that at excessively high temperatures most of the vibrations are too rapid to emit light, and hence, even if our elements are truly such, they might fail to yield a spectrum under nebular conditions."

In concluding this outline of Mr. Skertchly's work, we cannot refrain from complimenting him upon the care he has bestowed upon this subject, and from expressing our belief that he has formed a very solid nucleus from the nebulous matter that is scattered through a wide range of knowledge. H. B. W.

II.—Revue de Géologie pour les Annees 1876 et 1877. Par M. Delesse et M. De Lapparent. (Paris: F. Savy, 1879.)

THE onward progress of geology is fully evidenced by the numerous works which of late years have been published bearing on that science. Distributed as separate treatises, or as memoirs and papers in various scientific journals, or in proceedings of societies, and in different languages—the majority of them might be comparatively unknown to many geologists, without some general record of their place of publication. This desideratum has been fulfilled by the "Revue de Géologie" of MM. Delesse and De Lapparent, of which fifteen volumes have now appeared, and to which object the "Geological Record" and "Revue Géologique Suisse" have also contributed. With the fifteenth volume of the "Revue de Géologie," the Editors have brought their French record of geological literature up to 1877. Commencing in 1860, the series now published contains a vast amount of useful information with regard to the various publications issued during the period, and so arranged as to be easily referred to. The subjects in this, as in the preceding nine volumes, are classed under the chief divisions adopted by Prof. Dana in his Manual of Geology,—physiographical, lithological, historical, geographical, and dynamical geology. As in preceding years, the authors have endeavoured to present a concise but faithful and methodical analysis of the various memoirs which have contributed to the advancement of geological science during the years 1876-77. J. M.

III.—Contributions to the Knowledge of the Eruptive Rocks in the District of Saar and Moselle.—"Beiträge zur Kentniss der Eruptivgesteine im Gebiete von Saar und Mosel." Von Prof. Dr. A. von Lasaulx. pp. 76, with 2 coloured plates. (Bonn, 1878.)

IN this treatise the author describes the mode of occurrence, the megascopic, and the microscopic characters of a number of eruptive rocks which have hitherto been, with a few exceptions, designated Greenstones. The rock first described is the Diabase-Diorite of Kürenz, near Trier. Then follow descriptions of an

Amphibolite from Olmuth; Diorites from Wilmerich, from Winkelhornfloss, near Schillingen, from the Grinburg, near Wadrill, and from Paschel, near Zerf. A decomposed dioritic rock from Schoden on the Saar is also described. Diabases from Kellenbach, Förstelbach, Hockweiler, near Trier, Saarburg and other localities, are likewise treated of at some length. Descriptions of numerous Melaphyres from different localities are followed by an account of what is headed as a Porphyry, from Rhaunew, which is shown to be a fine-grained granitic rock with porphyritic felspar crystals.

The descriptions are clear, and the drawings at the end of the treatise are well calculated to explain those portions of the text which need illustration, as they are rendered in the slightly diagrammatic manner which characterizes the microscopic drawings of many of the leading continental petrologists. F. R.

IV.—The American Quarterly Microscopical Journal. Containing the Transactions of the New York Microscopical Society. No. I. (New York, October, 1878.)

We heartily wish Mr. Romyn Hitchcock, the Editor of the above, all possible success in his arduous but much needed undertaking.

That the United States should have been hitherto without a journal of Microscopy is certainly an anomaly, considering the numberless other scientific publications of which it can proudly boast, and the immense field there open for all comers to work in.

We trust, therefore, that this attempt to supply a known defect may meet with a fate quite the reverse of that which attended its predecessor the "Lens."

The part before us is got up somewhat in the style of our lately defunct "Monthly Microscopical Journal," but printed on better paper, and illustrated with, we venture to add, still more excellent plates.

Though the present number does not contain any papers of special interest to the geologist, still we nevertheless trust that from time to time we may see, and be able to record as occurring in its pages, articles on Microscopic Geology. B. B. W.

REPORTS AND PROCEEDINGS.

Geological Society of London.—I.—December 4, 1878.—Henry Clifton Sorby, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "On some Mica-Traps from the Kendal and Sedbergh Districts." By Prof. T. G. Bonney, M.A., F.R.S., F.G.S., and F. T. S. Houghton, Esq., B.A.

The rocks described by the authors are mapped by the Geological Survey on Quarter Sheets 98 N.E., 98 S.E., and 97 N.W., and in parts briefly mentioned in the accompanying memoirs, under the generic name mica-trap. Seventeen examples are described macroscopically and microscopically, and of eight chemical analyses are given. It appears better to call one a porphyrite and two diorites (micaceous varieties). The remainder are all characterized by abundance of mica (biotite). Augite also appears to have been generally a constituent; but it has almost invariably been replaced by secondary products, calcite, dolomite, viridite, etc. Three are crystalline in structure; one of these is named minette, the others kersantite. The remaining eleven show a microcrystalline or crypto-crystalline base. It is proposed to call eight of them minette-felsite, the rest kersantite-porphyrite. These rocks commonly occur in rather narrow dykes; they are intrusive in Silurian strata, and, in the authors' opinion, are undoubtedly true igneous rocks.

2. "Pleistocene Notes on the Cornish Coast near Padstow." By W. A. E. Ussher, Esq., F.G.S.

In this paper the author described certain deposits seen in a small bay near St. Enodock's chapel, and known as Daymer Bay, and in section at Greenway cliffs. The former included a portion of raised beach, and a reef of consolidated old beach and a peaty deposit below high-water mark, the raised beach indicating a depression of from 5 to 10 feet and a subsequent elevation of more than that amount, during a pause in which the lower beach was formed. The further elevation of the coast was sufficient to favour the growth of forests furnishing the peaty bed, which a subsequent subsidence has brought down to its present level. Greenway cliffs consist of grey slates, resting against which, in two places, are old consolidated blown sands; about 5 feet above high-water mark is a raised beach, near which the face of the cliff consists of "head" capped by gravel. The author discussed the relative ages of these deposits, and inclined to regard the gravel as a fluviatile deposit, and the stony loam or "head" as an ancient talus or flood-gravel, both deposited before the raised beach.

3. "The Pleistocene History of Cornwall." By W. A. E. Ussher, Esq., F.G.S.

In the first part of this paper the author, from his own observations and the writings of other geologists, gave detailed descriptions of the various superficial deposits of Cornwall as exposed in numerous coast-sections.

In the second part he discussed the relative ages of these deposits, for which he proposed the following classification:—

1. The oldest beds described are patches of quartzose gravel, found up to 400 feet above the present sea-level; these are regarded by the author as of fluviatile origin, and as being possibly redeposited Tertiary beds. Their age may be any thing between Cretaceous and Glacial.
2. Boulder-gravels, from 40 to 50 feet above sea-level.
3. Raised beaches, up to 15 feet above sea-level.
4. Old blown sand closely associated with the raised beaches.
5. "Head" or talus of angular fragments lying upon the raised beaches, and therefore of younger date than the latter.
6. Stream tin-gravels, evidently older than the forest stratum.

7. Submerged forests, evidently occupying a long period subsequent to the deposition of the stream tin-gravels.

8. Recent marine and fluviatile deposits.

In conclusion he remarked on the paucity of superficial deposits in Cornwall, the absence of evidence of glacial conditions, and the proofs of great changes in the level of the area.

II.—December 18, 1878.—1. "On Remains of *Mastodon* and other Vertebrata from the Miocene Beds of the Maltese Islands." By Prof. A. Leith Adams, M.B., F.R.S., F.G.S. The author recognized the following Maltese formations:—

Upper Limestone.—Maximum thickness over 250 feet, passing into a sandy rock, and that into a hard red limestone. Fossiliferous, containing 4 Brachiopoda, several Lamellibranchs and Gasteropods, and 25 Echinodermata (10 being peculiar).

Sand Bed.—Maximum thickness about 60 feet, variable in character, characterized by vast abundance of *Heterostegina depressa*; 15 Vertebrata.

The Marl Bed.—Maximum thickness over 100 feet, but sometimes almost wholly thinned out. Organic remains rarer than in the Sand Bed.

The Calcareous Sandstone.—Maximum thickness rather over 200 feet. Contains bands of nodules, of which the second is rich in organic remains. Hence come the noted teeth of Squalidæ. Among its invertebrate fauna are many Pectens, with other Lamellibranchs, Gasteropods, and Brachiopods. Also 22 species of Echinodermata.

The Lower Limestone.—Maximum thickness over 400 feet. *Scutella subrotunda* and *Orbitoides despansus* are abundant in the upper part, and it is generally fossiliferous.

In a nodule-seam in the Calcareous Sandstone in the Island of Gozo two rather imperfect teeth of a *Mastodon* have been found. Both are penultimate molars. They agree most nearly with the teeth of *Mastodon angustidens*, but the characters are not sufficiently well preserved to differentiate the species with certainty.

The same formation has furnished teeth of a *Phoca* to which the specific name *rugosidens* has been given by Prof. Owen. Large teeth referable to the Phocidæ are found in the nodule-seams of the Calcareous Sandstone and in the Sand Bed; the Marl Bed has also furnished a portion of a jaw.

The Woodwardian Museum contains a part of a jaw of *Squalodon*, evidently from a nodule-seam of the Calcareous Sandstone (found by Scilla circ. 1670). The Sand Bed and Calcareous Sandstone have furnished remains of more than one species of *Delphinus*, and large-sized Cetacean vertebræ are found in nearly all the beds, especially the Sand Bed. *Halitherium* has been obtained from the Sand Bed, Marl Bed, Calcareous Sandstone, Lower Limestone, and (?) Upper Limestone.

One specimen of *Ichthyosaurus gaudensis*, Hulke, has been furnished by the Calcareous Sandstone; the same has also furnished *Melitosaurus champsoides*, *Crocodilus gaudensis*, and *Sterrodus melitensis*. *Myliobates toliapicus* and allied species have come from all the deposits except the Upper Limestone. *Ætobates subconversus* from the Sand Bed and Marl. The Squalidæ are abundant from all the deposits except the first. There are ten species belonging to the following genera:—*Carcharodon, Carcharias, Oxyrhina, Hemipristis, Corax, Odontaspis, Lamna.* Remains of *Notidanus, Platax,* and *Diodon* have also been found.

2. "Dinosauria of the Cambridge Greensand." Parts I.—VII. By Prof. H. G. Seeley, F.L.S., F.G.S.

The author stated that this paper was founded upon the collection of more than 500 Dinosaurian bones preserved in the Woodwardian Museum, for the opportunity of studying of which he was indebted to the kindness of Prof. T. McKenny Hughes. He described the conditions under which the specimens occur, and accounted for the apparently worn state of the bones as the results of exposure to the air, and subsequent maceration.

I. "Note on the Axis of a Dinosaur from the Cambridge Greensand." This bone was said to be very similar to the axis from the Wealden previously described by the author (Q. J. G. S. vol. xxxi. p. 461), but differed in the neural arch being supported on pedicels of the centrum, in both articulations for the rib being on the centrum, in the compressed form of the odontoid process, and in the subhexagonal form of the oblique posterior articular surface of the centrum. There is no indication of a wedge-bone beneath the anterior articulation. The condition of the axis in other Dinosaurs, such as *Zanclodon,* was indicated, and reasons given for regarding the structure of the bone as a modification of the Crocodilian type.

II. "On the Vertebral Characters of *Acanthopholis horridus,* Huxley, from the base of the Chalk-Marl near Folkestone." The author stated that only dorsal and caudal vertebræ of *Acanthopholis* are at present known. The dorsal vertebræ have the visceral surface well rounded, the articular ends subovate, and the centra laterally compressed. The early caudal vertebræ are deep, with strong compressed transverse processes, zygapophyses directed well forward, and the neural spine directed upward and backward. The centrum is inclined obliquely forward; the facets for the chevron bone large, and the anterior articulation circular. The later caudals have nearly the same absolute length of centrum, and the transverse process is first reduced to a tubercle, and afterwards disappears entirely. A deep channel is developed on the underside of the centrum, and two more or less marked ridges run along each side of the centrum, making the articular ends subhexagonal.

III. "On the Skeleton of *Anoplosaurus curtonotus,* Seeley." This genus and species are founded upon an associated series of about 80 bones from near Reach. The remains include a portion of the left ramus of the lower jaw, 5 cervical (axis and atlas missing), 13 dorsal, 6 sacral, and 8 caudal vertebræ (the tail being imperfect), the coracoids (one imperfect), the proximal end of the scapula, the proximal and distal ends of the humerus, the proximal and distal ends of the femur, a small fragment of the ilium, small portions of ribs, and fragments of the metatarsals and phalanges. The teeth were placed close together in sockets, 13 occurring in a space of $2\frac{1}{4}$ inches. The general form of the vertebral centra indicates a convex curve in the back and sacrum, and a concave curve in the neck and tail, rendering it probable, in conjunction with the great development of the sacrum, that the animal affected a semierect attitude. The sacral vertebræ, as preserved, are all separate. The scapula is remarkably thick, with a strong spinous or acromioid process. The femur shows distinctive Dinosaurian features, but presents a form that has not previously been described. The vertebral centra indicate a near affinity to *Acantholpholis*; but no dermal armour has been met with, and the caudal vertebræ present differences which seem to justify its location in a distinct genus.

IV. "On the Axial Skeleton of *Eucercosaurus tanyspondylus*, Seeley." This genus is founded on an associated series of 19 vertebræ and a neural arch from Trumpington. Four dorsal vertebræ are preserved, which considerably enlarge towards the sacral region, so that probably the vertebral column was carried in a more than usually erect position. The underside of the centrum in the early part of the series has an angular or squeezed form; but this appearance is lost in the hinder centra. The sacral region is represented by 3 vertebræ; there were probably, in all, 5 or 6. Twelve early caudal vertebræ are preserved; these become unusually elongated and prismatic posteriorly. The chevron bones were at first very large, but are small when the articular face of the centrum has acquired the hexagonal outline. The neural arch in the caudal region was very depressed. This genus was considered to be closely related to *Acanthopholis*, though the vertebræ differed so greatly in form.

V. "On the Skeleton of *Syngonosaurus macrocercus*, Seeley." This genus is founded on a series of 19 vertebræ, representing the neck, back, sacrum, and tail. It shows affinities to several Dinosaurian types, especially *Eucercosaurus* and *Iguanodon*. The early dorsal vertebræ are remarkably compressed, and the neural arches are entirely united to the bodies of the vertebræ throughout the series. In the lower dorsal region the ridge on the visceral surface disappears, and the centrum becomes deep. The visceral ridge reappears in the sacrum. The caudal vertebræ are at first compressed, and have the articular faces oblique and slightly procœlous; the chevron bones have a large single facet united by suture to the lower half of the articulation. In these vertebræ the visceral surface is rounded and narrow. The proximal end of a humerus and distal ends of both humeri were obtained; they are of small size. Several metatarsal bones and phalanges have also occurred, and are large in proportion to the other remains. In doubtful association with these bones were 11 pieces of dermal armour, closely resembling that of *Acanthopholis*.

VI. "On the Dorsal and Caudal Vertebræ of *Acanthopholis stereocercus*, Seeley." This species was founded on a small associated series of vertebræ, one of which is an imperfect cervical, 2 dorsal, and 8 caudal. The species differs from *A. horridus*, Huxley, in the form of the centrum, in the different character of the facets for the chevron bones, and in the deeper median channel of the visceral surface. The caudal vertebræ slightly decrease in length posteriorly.

VII. "On a small series of Caudal Vertebræ of a Dinosaur, *Acanthopholis eucercus*, Seeley." This species was founded on an associated series of 6 caudal vertebræ, which differed from those in the tail of *A. horridus*, in the centrum being more elongated and constricted, and in the rapid diminution in length of the centra posteriorly. The species is slightly larger.

III.—January 8, 1879.—1. "On some Tin-deposits of the Malayan Peninsula." By Patrick Doyle, Esq., C.E. (Communicated by the Rev. T. Wiltshire, M.A., F.L.S., F.G.S.)

The tin-ore of the Malayan Peninsula is obtained from "streamworks" in an alluvial plain extending between a range of granitic mountains and the sea. The author describes the mines of the district of Larut Perak. The ore is got in open workings at an average depth of about 10 feet. The tin-bearing stratum has an average thickness of 4·87 feet; it is overlain by stratified sand and clay, and rests upon either porcelain clay or, sometimes, a sandstone. The ore varies from a fine sand, near the sea, to a coarse gravel, near the mountains, and is mixed with quartz, felspar, mica, and schorl. The author is of opinion that the stratum of ore has been derived from the granite of the mountain range, in which it still occurs in veins, by denudation, and under conditions which still exist, though in a modified form.

2. "Description of Fragmentary Indications of a huge kind of Theriodont Reptile (*Titanosuchus ferox*, Owen), from Beaufort West, Gough Tract, Cape of Good Hope." By Prof. R. Owen, C.B., F.R.S.

The author stated that among the fossils recently sent to the British Museum from the Cape of Good Hope by Mr. T. Bain, there were two boxes containing specimens of a most unpromising character, there being in them no entire bones, but only numerous more or less water-worn fragments. Among these was found a portion of a maxillary showing some traces of teeth; and sections having been made of this bone, the remains of several teeth were displayed, including a canine, the preserved portion of the socket of which was 4½ inches long. From the number and mode of implantation of the teeth, the author concluded that the animal to which they belonged resembled the Theriodont genera *Galesaurus* and *Galenops*. The anterior portion of the left ramus of the lower jaw, measuring 7½ inches in length, showed teeth presenting close analogies with those of Theriodonts, and this alliance was confirmed by the study of other fragments. Some of the characters presented by these remains seem to suggest affinities with the carnivorous mammalia, such as have been already indicated by the humeri of Theriodonts and Carnivores.

The canine tooth of the new South-African reptile, which the author proposes to name *Titanosuchus ferox*, was six times as long as that of the allied form *Lycosaurus;* and we have in *Titanosuchus* evidence of a carnivorous reptile of more carnassial type than

Machairodus and other Felines. The author suggests that *Titanosuchus* found its prey in the contemporary *Pareiosauri*, Oudenodonts, and Tapinocephalans of the same locality.

3. "Notes on the Consolidated Beach at Pernambuco." By J. C. Hawkshaw, Esq., M.A., F.G.S.

The consolidated beach at Pernambuco, which has already attracted considerable notice, is a ridge of sandstone from 25 to 75 yards wide, and, as shown by borings made under the author's direction, from 10 to 13 feet thick. The landward or higher edge is nearly at the spring-tide high-water level, and it slopes seaward; the river (with a depth of 28 feet at low water 60 feet from the rock) flowing along the former face. The rise and fall of spring tides is 7 feet. Beneath the above rock is a stratum of sand with shells and stones about 8 feet thick, and then a second layer of sandstone rock.

The consolidated beach is cemented by carbonate of lime, which the author considers to have been deposited by the action of water percolating through the rock, probably when the level of the land differed somewhat from what it is at present. He thinks it possible that this and other similar beaches on the Brazilian coast may mark periods of repose in the slow vertical movements which the coast has undergone.

CORRESPONDENCE.

ON THE FORMER CLIMATE OF THE POLAR REGIONS.

SIR,—In the GEOLOGICAL MAGAZINE for December, 1878, page 552, in a paper by the Rev. O. Fisher, M.A., on "The Possibility of Changes in the Latitudes of Places on the Earth's Surface," the following passage occurs in reference to the question of the possibility of the crust of the earth slipping over a fluid substratum, thereby causing changes of latitude:—"That theory belongs to Dr. Evans; and he has ably defended it against Dr. Haughton's somewhat formidable objections in his recent address to the British Association at Dublin. The supposition alternative to Dr. Evans', by which Dr. Haughton would account for a former warm climate at the Pole through residual heat in the earth, has, I think, been disposed of by anticipation in Sir W. Thomson's paper on the Secular Cooling."

I am not at all prepared to admit either horn of the foregoing dilemma, but shall confine myself at present to the first.

Dr. Evans' address was delivered at the opening of the Geological Section of the Association Meeting, and my paper, showing the impossibility of accounting for the Tertiary plant-remains in the Arctic Regions by any change in the position at the Pole, was the last paper read before the Geological Section of that meeting.

I believe that I am correct in stating that neither the President, Dr. Evans, nor any geologist present, gave anything like a satisfactory answer to what the Rev. O. Fisher has called my "somewhat formidable objections."

My contention, in brief, was this, that the Tertiary plant-remains indicating a climate similar to that of Lombardy (so far as heat is concerned) are so situated round the North Pole that no possible change in the position of that Pole (even were such permitted by mechanical considerations) would give them the climatic conditions as to temperature which they require. It was urged at the meeting, as an objection to my view, that the presence of evergreens among the Arctic Tertiary plants was inconsistent with the prolonged absence of light, which they must have sustained if the Pole were in its present position. To this, my reply was the following statement by Professor W. R. McNab, M.D., of the Royal College of Science:—

"4, Vernon Parade, Clontarf, *7th April*, 1878.

"Dear Dr. Haughton,—I fear I cannot give you a direct answer to your question, and I have not found any papers on the subject in the 'Botanischer Jahrsbericht,' Sachs' 'Lehrbuch der Botanik,' in Sachs' 'Handbuch der Experimental-Physiologie der Pflanzen.' The general facts of the case can, however, be very readily stated.

"Plants containing green chlorophyll grains, when placed in darkness, partial or complete, change colour from the destruction of the chlorophyll. Sachs says (Text-book of Botany, page 669) that in the leaves of rapidly-growing Angiosperms the absorption and disappearance of the chlorophyll takes place in a few days if the temperature be high. He adds, Cactus stems with slow growth, and the shoots of Selaginella, remain green for months in the dark. It is probably true also of Conifers, as I have seen them kept in the dark during the winter months without injury. This I saw in Berlin. Large plants requiring protection from the cold were laid on their sides, and a covering of mats and leaves on a wooden frame placed over them.

"The evergreens in your list are all *Conifers*, and I am of opinion that the absence of light for a considerable period would not injure them.

"It is well known that *cold* alters the colour of the leaves of many Conifers at once, but in your paper you state the temperature at 48° F., a temperature much too high to influence the colour.

"Your question places an isolated physiological fact in a very important light, at least it appears to do so to me. I give it in Sachs' words (Text-book, page 665): 'If the temperature is sufficiently high, the green colouring substance is found in the *cotyledons* of *Conifers* and in the leaves of Ferns, in *complete darkness* as well as under the influence of light. . . . Provided, therefore, that the temperature is favourable, the chlorophyll in the cotyledons of Conifers and the leaves of Ferns does not require light in order to assume its green colour, while that in Angiosperms does require it, and in both cases the change does not take place at low temperature.'

"My answer to the objection that has been made to your paper is this: '*Grant that the evergreens cannot stand prolonged absence of light—that refers to Angiospermous forms. Here all the forms are Coniferous; and Coniferous plants with Ferns have the peculiar property of forming green chlorophyll grains in the dark.*'

"I think a few evergreens do stand prolonged darkness, as I have certainly seen myrtles and rhododendrons placed during the winter in *very dark sheds*.

"As I can only refer to the books in my own library to-day, I shall try to find out some reference to the St. Petersburg observations, and let you know the result in due course.—I am, very truly yours,

(Signed) W. R. McNab."

"Rev. Prof. Haughton, F.R.S., etc., etc."

During the discussion on my paper in the Geological Section, it was observed by Mr. Pengelly that "magnolias" are mentioned by Professor Heer as occurring among the Greenland Tertiary plants. To this my reply was, that although some of the magnolias are evergreens, some of them also have deciduous leaves, and that the occurrence of plants or trees having deciduous leaves should cause us no surprise in the Arctic Regions, provided a suitable temperature were provided for them.[1]

I cannot give here all the details explained in my paper, but I claim to have surrounded the North Pole with such a network of Lombardic plants, requiring Lombardic heat, but not Lombardic light, as to render the escape of the Pole from its present position as difficult as that of a "rat in a trap surrounded by terriers."

If the Lombardic light as well as heat were present in these Tertiary times, it would be difficult to explain the *absence* of a multitude of evergreen plants which require light to develope chlorophyll grains. Such evergreen plants ought to have migrated from North America and Europe into Greenland as easily and as rapidly as the peculiar groups of evergreens found there in Tertiary times.

In my opinion, the natural selection in the Tertiary Flora of Greenland of such evergreens only as require Lombardic heat, but can dispense with Lombardic light, is a fact which my opponents in the Geological Section not only did not answer, but entirely failed even to see the force of. S. Haughton.

Trinity College, Dublin, 17*th January*, 1879.

FACTA NON VERBA.

Sir,—The Devonian question being already hampered with so much theory, I venture to hope that you will insert the following facts, arrived at after a series of traverses by almost all the river-courses in North Devon. Prof. Hull's description of the rocks of this county and West Somerset contains serious errors, into which I am sure he would not have fallen had he been acquainted with the area.

Firstly. The Pilton beds consist of bluish grey and grey schistose and slaty rocks, with local developments of grey and brownish grit. The calcareous element is represented by thin, trivial, and impersistent beds of limestone.

Secondly. The Baggy Sandstones are buff-grey and brown, apparently confined to a definite horizon, but by no means equally developed thereon; they rest upon olive slates. For stratigraphical survey lines these may be included in the Pilton beds, from which they cannot, in disturbed districts, be readily distinguished.

Thirdly. The Pickwell Down beds are strangely mixed up with the Morthoe Slates in Prof. Hull's table, which would be fatal to the supposition of unconformity between them (vide Geol. Mag., 1878, p. 531, lines 18 and 19). The Pickwell Down series is distinguishable through North Devon by its characteristic interstratification of slates, not shales; these are almost invariably lilac or purple, and toward the base of the division seem to pass into the Morte group by intercalation with buff and greenish slates, especially on Exmoor.

Fourthly. The Mortehoe slates are simply an unfossiliferous upper portion of the Ilfracombe group; the former being greenish and glossy; the latter grey, bluish, steel grey, and silvery, with local

[1] So far as I can understand, it would be difficult, if not impossible, to distinguish between evergreen magnolias and those with deciduous leaves, in fossil remains.

developments of limestone bands near Ilfracombe and in West Somerset. It is impossible to fix any definite boundary between them.

Fifthly. The upper beds of the Hangman group are very coarse and siliceous, silvery red-stained shales being sometimes intercalated; the lower beds are generally flaggy and of a grey colour.

Sixthly. The Lynton zone is represented by grits, generally breaking in even tabular layers, schists, schistose grits, and slates, of a uniform warm grey tint.

Seventhly. The Foreland grits are generally fine, flaggy, cream-coloured, dull-grey, brown, reddish or greenish grits, with beds of red grit, sometimes massive; they very seldom contain slates.

Throughout the series conglomerate is conspicuous by its absence. The Drayton and Slade group, if not another name for the olive slates which form the base of the Pilton beds, below the *Cucullæa* zone, has no existence; and if the *Cucullæa* and olive slates are to be regarded as a separate division, the term Marwood used by Prof. Hull is much the most suitable, owing to the presence of the Hangman lower down.

W. A. E. Ussher.

Bear Street, Barnstaple, *Dec.* 1878.

THE NORTH DEVON SECTION.

Sir,—Professor Hull, having depended on the writings of others for his knowledge of the North Devon rocks, has obtained the result which usually follows this method of inquiry. His proposed classification looks, no doubt, very well in print, but there are two or three points to which any one knowing the locality must take exception.

At page 531 it is suggested that "it will probably be found on a careful re-survey of North Devon, that the Pickwell Down Sandstones are somewhat unconformable to the underlying beds." Now, as a matter of fact, so far from this being the case, there is a gradual passage from the slates to the sandstones; first slates alone, then slates with layers of sandstone; next, sandstones with layers of slate, and finally the Pickwell Down Sandstone itself. With regard to a *re*-survey of this district, it must be remembered that the present map was constructed, not by the Geological Survey, but by De la Beche, working as an amateur; and the only boundary-line shown on it is that separating the Devonian and the Carboniferous. In 1865 I laid down for the first time, on the one-inch scale, the various subdivisions of the North Devon series from personal observations made during the preceding three years. The nomenclature I then published I had occasion to alter shortly afterwards by the substitution of *Cucullæa* zone for Marwood zone,[1] and the adoption of "Pickwell Down Sandstone" for the upper portion of the Morthoe group. Mr. W. A. E. Ussher, F.G.S., of the Geological Survey, who has now been engaged for some months in mapping the river valleys, informs me that, after going carefully over the ground, he has not only adopted these subdivisions, but also the general horizons as shown on my map.

As far as the Drayton and Slade beds are concerned, they have been placed by Professor Hull in a most convenient position in his

[1] For reasons see Quart. Journ. Geol. Soc., vol. xxiii. p. 374.

classification, as passage-beds between the Baggy or Marwood bed and the Pickwell Down Sandstone; though to do this they must be transported bodily at least one mile to the south. I may also notice the misapplication of the term Baggy and Marwood *slates*—this bed consisting principally of sandstone; the thin intercalated beds of olive slates and shale being the exception.

In the Morthoe group I am not aware of any "purplish" slates. Their real colour is a silvery grey. The purplish slates included by Professor Phillips in the then undivided Morthoe group lie *above* the Pickwell Down Sandstone, and form the passage between it and the *Cucullœa* zone.

The suggestion as to the Foreland Sandstone being Upper Silurian must be taken for what it is worth; as with a few most indefinite traces, which may be attributed to organic remains, it is impossible to fall back upon palæontological evidence.

Another objection to Professor Hull's explanation of the North Devon section is, that he seems to ignore altogether the existence of Upper Devonian fossils. The Ilfracombe group with its limestones undoubtedly belongs to Middle Devonian age, and if both the Pilton beds and the *Cucullœa* zone are transferred to the Lower Carboniferous, he leaves no fossiliferous bed whatsoever of Upper Devonian age; but has evidently trusted that "Drayton and Slade" might serve to fill up the gap, or that an unconformity might exist at the base of Pickwell Down to account for it.

Pilton, Barnstaple, *Dec.* 16, 1878. Townshend M. Hall.

MIOCENE FLORA IN ARCTIC REGIONS.

Sir,—Voluminous and elaborate writings have issued from the press, in almost every possible form, to account for the existence of a Miocene flora in Arctic regions, without, I need scarcely say, any satisfactory result. I venture in a few lines to suggest an element of change, or rather a new application of one, which seems to have escaped notice. It consists in the transfer of water by the Gulf Stream from Equatorial to Polar Regions. This is incessantly in progress, and it would be difficult to ascertain the immensity of the volume of water which is thus transferred, simply through the agency of the sun. It would be equally difficult to ascertain the enormous quantity of ice which is amassed annually by the congelation of this water. It is the fact of its being so warmed which leads to its being conveyed nearer to the North Pole than it could be under other known causes, but the point must be reached when its fluidity, in great part at least, must cease.

Now, it appears to me, that, owing to this cause, there must be such an accumulation of ice as would tend, if the pressure were equably circumpolar, to depress the Equator; and, if it were lateral, as under circumstances it must be, to produce an obliquity of poles, in proportion to the bulk of the ice and its nearness to the Pole. With reference to this obliquity, I might merely add Q. E. D., and submit the problem to the public in the naked simplicity of truth, reserving to myself the privilege of defence or explanation as occasion may require. I will only remark that an interesting analogy may be traced between the evaporation of the water of the ocean and the impulsive motion of the Gulf Stream, both alike due to solar heat; only the vapour is liable to be converted into snow much nearer home; but the Gulf Stream rolls on till its heat is expended and it is converted into ice, and so its function in the economy of Nature is discharged, which may not at present have been fully appreciated.

25, Prince of Wales Road, Norwich, John Gunn.
January 15, 1879.

THE HITCHING STONE.

Sir,—In the British Association Report for 1874, page 196, the "Hitching Stone" on Sutton Moor, near Keighley, is described as a boulder. As I surveyed that country, I may perhaps be allowed to say that in my opinion the Hitching Stone is not a boulder. It is simply a block of Millstone Grit, weathered in place, the rest of the layer having, in the immediate neighbourhood, been removed by denudation. In a broad sense, it forms part of the massive grit of which Hitching Stone Hill is composed. The stone stands on the escarpment of this grit, the base of which is marked by Hitching Stone Spring, about 30 feet below. This bed of grit is considered by my colleagues and myself, on stratigraphical grounds, to be a portion of the Rough Rock. Hanging Stone Quarry is in the grit of Earl Crag, which is the principal bed of the Third Grit Series.

The most remarkable thing about the Hitching Stone is that it is perforated by a large hole, out of which a tree, a Lepidodendron as far as I remember, has weathered. A vertical section across the hole is of an oval shape, measuring $15\frac{1}{2}$ inches by 12, the longer axis horizontal or rather along the bedding plane: thus we see the flattening produced by the weight of the overlying sand on the decaying trunk; and we also see that the stone is standing in its original position in the bed of grit of which it formed a part.

Bridlington Quay. J. R. Dakyns.

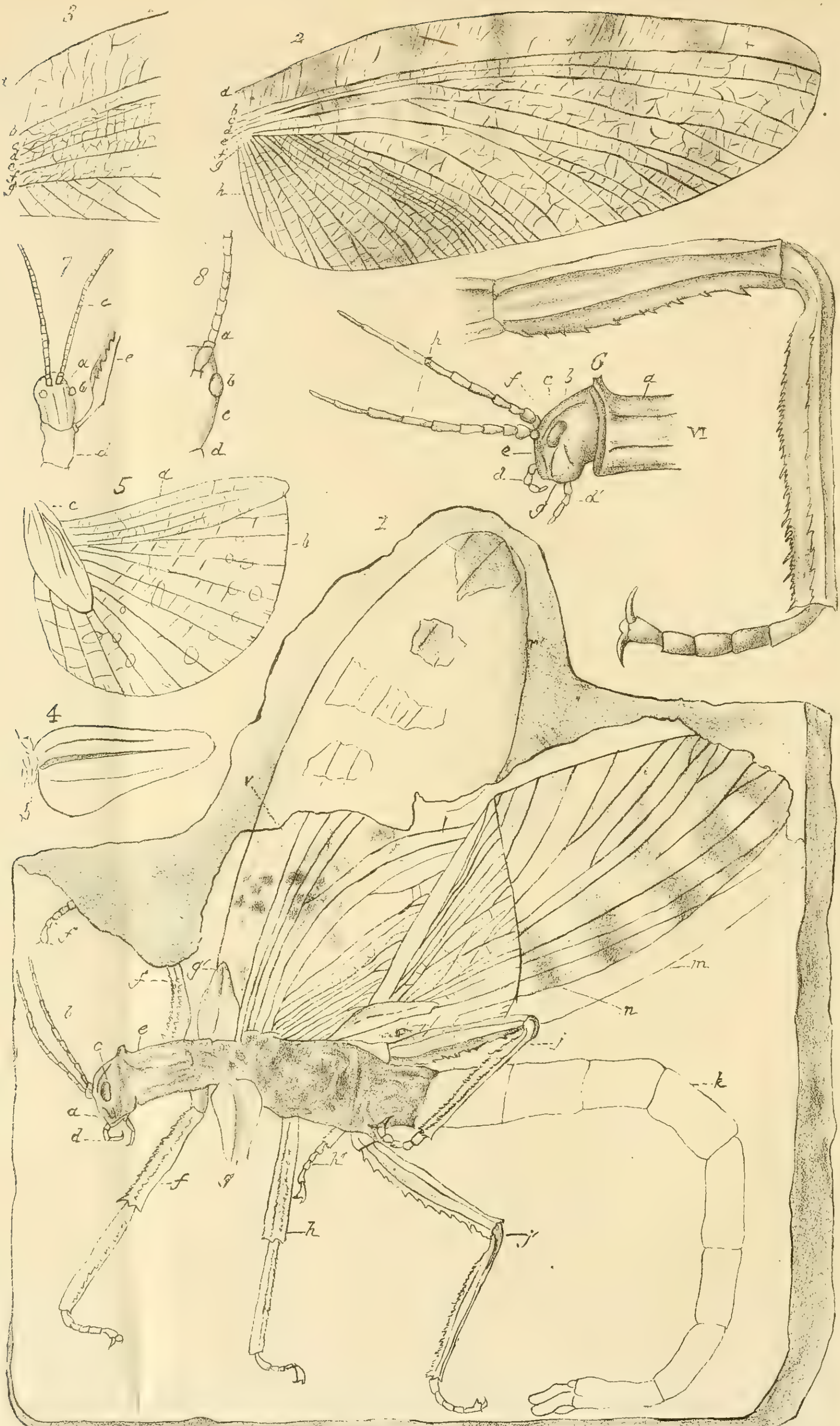
OBITUARY.

THOMAS SOPWITH, M.A., F.R.S., F.G.S.

Born 1803. Died 1879.

We regret to announce the death of Mr. Thomas Sopwith, F.R.S., at Westminster, on the 16th January last. He was born in 1803, at Newcastle-on-Tyne, and was for nearly 50 years extensively engaged as a civil engineer in mining, railway, and other works, both in this country and on the Continent, and was the author of several works on architecture, isometrical drawing, and mining. In 1838 he was appointed Commissioner for the Crown under the Dean Forest Mining Act, and in the same year a communication made by him to the British Association led to the establishment of the Mining Record Office. He was a member of many of the leading scientific societies, and one of the early members of the Institution of Civil Engineers.—*Daily News*, Jan. 17, 1879.

Erratum. In Mr. Dakyns' letter in the Geol. Mag. January, 1879, p. 46, line 11 from bottom, the words *river base* should have been *river Ouse*.



G.M. Woodward del. West Newman & Co. imp.

Protophasma Dumasii, Brong. Coal Measures, France.

(To face p. 97.)

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. VI.

No. III.—MARCH, 1879.

ORIGINAL ARTICLES.

I.—On a New Genus of Orthopterous Insects of the family Phasmidæ (*Protophasma Dumasii*), from the Upper Coal-measures of Commentry, Dept. Allier, France.[1]

By M. Charles Brongniart,
of the Museum of Natural History, Jardin dės Plantes.

(PLATE IV.)

WE possess only a few elements of the Insects of the Coal Period—Articulata are rare in these beds, and it is only after long research that we are able to collect sufficient materials for a special work on the Entomology of this epoch.

Prof. Goldenberg has made us acquainted with the fauna of the Coal-measures of Saarbrück, and has quite recently (1877) published the second part of his work, entitled "Fauna Saræpontana Fossilis," in which he describes fairly preserved wings of Neuroptera and Orthoptera, one of which (*Eugereon Boeckingii*) also exhibits the remains of the body.[2]

In America, Mr. Samuel H. Scudder has ardently studied the Insect-remains from the Coal-measures of the United States. Lastly, Dr. H. Woodward has published several works on the fossil Articulata, and amongst others, in 1876, an interesting note on a very complete Orthopter from the Coal-measures of Scotland (*Lithomantis carbonarius*).[3]

The insect-remains found in the Coal-measures belong principally to the running Orthoptera, such as the Blattidæ, some species of Mantidæ, and some Neuroptera, such as *Termites* and *Hemerobius*.

Prof. Goldenberg has given the name of *Fulgurina* to certain insects, which would indicate the presence of Hemiptera in the Coal epoch.[4]

[1] Translated from the "Annales des Sciences Naturelle," 6e Série, 1878, Zoologie, Tome vii. Art. No. 4, by A. P. Wilson, Esq.

[2] See papers by Dr. Anton Dohrn on *E. Boeckingii*, Paleontographica, 1866, Bd. xiii. p. 333, taf. xli. and 1869, Bd. xvi. p. 129, taf. viii.

[3] See Quart. Journ. Geol. Soc. 1876, vol. xxxii. p. 60, pl. ix. fig. 1.

[4] I possess some wings of insects very like those figured and described by M. Goldenberg, but more complete, and showing the reticulations of the wing, but

I am indebted to my friend, M. Grand'Eury, for the opportunity of adding a new form to the running Orthoptera hitherto described.[1]

It was obtained from the Upper Coal-measures of Commentry, Allier.

I ought at the same time to describe several other fossil Articulata from St.-Étienne, which this able palæontologist has procured for me, but the very perfect state of preservation in which this fossil has been found, and the interest of its zoological affinities, induces me to make it known immediately.

The fossil is sufficiently well preserved to be seen, as represented in our Plate, without the aid of a magnifying glass, and we at once recognize an Orthopterous insect allied to the *Phasmidæ*, from which it differs, however, by certain characters to be presently referred to.

It is the first example of this family which has been obtained in a fossil state. On the intaglio one observes a brownish matter, which is darker in some places, and probably represents the substance of the integument.[2]

This magnificent Orthopter is preserved in profile lying on its right side, and every portion of its body except the abdomen is preserved. One can see (even with the naked eye) the limbs with their serrated margins; the head, the eye, the antennæ, and the palpi, lastly the elytra, of which one is very well preserved, and the fine second pair of wings, both of which are almost entire.

The *Phasmidæ* have been carefully studied by MM. Audinet-Serville, Westwood, and Gray. The last of these authors divides the "Spectres" into two great groups; the *Apterophasmina*, or wingless Phasmians, and the *Pterophasmina*, or winged Phasmians.

The Orthoptera included in the family of the PHASMIDÆ have very different forms. Some have the antennæ very long, and very slender (*Phasma*); others have them on the contrary short and very robust (*Cyphocrana*). One has the prothorax very short (*Phasma*); with others it is longer (*Prisopus*). Lastly, certain genera have the legs smooth and destitute of spines (*Phasma*); in others, on the contrary, they are very angular and serrated (*Diura*, Gray, *Cyphocrana*).

I shall not speak of the other genera, as they have no points of resemblance with our fossil, but proceed to compare it with the groups above cited in the latter part of my report.

I dedicate this beautiful Orthopter to my uncle, M. J. B. Dumas, Member of the Academy of France, and Perpetual Secretary of the Academy of Sciences.

they have no relations to the HEMIPTERA. They are, I believe, the wings of NEUROPTERA, which probably belong to the genus *Chauliodes*, of Westwood. (See J. O. Westwood, "Oriental Entomology," *Chauliodes subfasciatus*, p. 70, pl. 34, Fig. 5.)

[1] This fossil was discovered by M. Fayol, Engineer, in a bed of compact micaceous shale of the Upper Coal-measures of Commentry (Allier), in the Forest-pit, at 5 mètres 50 from the top of the great Coal.

[2] An analogous observation has been made on fossil plants; one has noticed the impressions of leaves in the Coal-measures, in particular the leaves of Ferns which could be detached from the surface of the shale and examined separately.

PROTOPHASMA, nov. gen.

Protophasma Dumasii,[1] Ch. Brong. (Plate IV. Fig. 1.)

			Length.	Breadth.	
Palpi			4 mill.	½ mill.	
Antennæ			21 ,,	⅔ ,,	
Head			9 ,,	6 ,,	
Prothorax			12 ,,	6·50 ,,	
Mesothorax			11 ,,	10 ,,	
Metathorax			11 ,,	11 ,,	
Abdomen			95 ? ,,	8 ,,	at the base.
Limbs	1st pair	femur	16 ,,	3 ,,	
		tibia	18 ,,	2 ,,	
		tarsus	10 ,,	1 ,,	
	2nd pair	femur	16 ,,	3 ,,	
		tibia	17 ,,	2 ,,	
		tarsus	8 ,,	1 ,,	
	3rd pair	femur	22 ,,	4 ,,	
		tibia	22 ,,	2·50 ,,	
		tarsus	10 ,,	1 ,,	
Elytra			13 ,,	7 ,,	
Wings			85 ,,	32 ,,	

The head of *Protophasma*, like the rest of the body, is seen in profile, and is of an oval form; it is longer than broad. Only one of the eyes is visible; it is rather long and prominent. The antennæ are attached to the front of the head in the centre; they are short, being only 21 mm. long. This character of the antennæ distinguishes the fossil from the *Phasmidæ*, properly so-called, and relates it to the genus *Cyphocrana*. The first joint is small and round; the second is larger, rather long, and increases in size at its distal end. I cannot clearly define all the other articuli, but those which can be seen distinctly are long, slender, and smooth.

The two palpi are well preserved; they are composed of four articulations almost of the same length; but the last is smaller than the others. One sees the upper labrum and one mandible; but the details cannot be clearly made out. The left mandible, which is alone visible on the surface of the matrix, is broad at its lower part.

Amongst the insects of this family the thorax is divided into three portions, the prothorax, the mesothorax, and the metathorax; and to each portion a pair of legs is articulated. In the living forms (*Phasma*) the prothorax is usually short, and it seldom in any case exceeds the length of the mesothorax (*Prisopus*). In *Protophasma* this section is longer than the mesothorax, in which character it resembles *Prisopus*.

The prothorax is cylindrical, and expands near the head so as to form a collar. It is the only part of the thorax which can be clearly seen; the other divisions are not so well preserved.

The abdomen, as already stated, is wanting in the fossil, but I am enabled approximately to estimate its probable length.[2] In order

[1] From πρῶτον 'first' and φασμα 'a spectre.'

[2] For example:—

Total length in millimètres of living forms.	Length of the thorax.	Length of the abdomen.
10	3	7
20	6	13·50
15	4·50	10
16	5·50	11

that these insects may maintain their equilibrium, the weight of the abdomen must at least be equal to that of the head and thorax; this relative proportion is constant in the living species; indeed, the abdomen generally exceeds the wings in length by one or two centimètres.[1] I am supported in this conclusion by a number of examples. For instance, in a Phasmian which has a total length of 16 centimètres, the head and thorax are $5\frac{1}{2}$ centimètres, and the abdomen 11 centimètres long. We see that the abdomen is twice as long as the head and thorax together.

In the fossil, this part, the head and thorax, measures $4\frac{1}{2}$ centimètres, the wings $8\frac{1}{2}$ centimètres; therefore, for the insect to be in a state of equilibrium, the abdomen must have been about 10 centimètres in length. I make this statement with all reserve. Another specimen of this insect, in a more perfect state, must be discovered in order to justify this conclusion.

The legs are perfectly preserved. The first two pairs are almost of equal length, but shorter than the third pair. They are all angular, and serrated, and in this respect they resemble those of *Cyphocrana*, and differ from those of PHASMIDÆ.

The trochanter is robust and short in the three pairs; in the first two pairs the femur is triangular, and is finely serrated along its inferior margin. The tibia is also angular and serrated, and is contracted near the proximal end; it terminates in two points at the distal end. The tarsi are alike in all the three pairs of feet, and are divided into 5 joints, of which the first is the longest; the last is provided with a pair of recurved, pointed, and widely-divergent claws, separated by a small rounded pad. The terminal articulation of the tarsus is broadest at its distal end; the three middle joints are of equal length. The third pair of legs are the longest. The femur is more robust and less angular than in the two other pairs, and is armed with seven sharp spines along its lower margin.

The tibia is angular, and bordered with fine denticulations, nine of which are larger than the rest, and placed at regular intervals apart.

The elytra of *Protophasma* do not offer any special characters, and are of moderate size, measuring about one centimètre in length. A stout longitudinal nerve marks the mesial line.

The true wings, or the second pair, are quite distinct, but are neither of them quite complete. Fortunately, what is wanting in one is preserved in the other, so that I have been enabled to reconstruct them, as seen in the accompanying plate (Pl. IV. Fig. 2). In the existing Phasmians, the wing is divided into two parts; the anterior portion supported by three or four straight nerves, which reach to the extremity of the wing, and united by irregular polygonal reticulations; the posterior portion traversed by slender and straight nerves, which radiate, fanwise, from the base of the wing, and which are united together by finely reticulating cross-nerves.

The wings of *Protophasma* differ from those of the living Phasmians. In the fossil form, the division between the anterior and posterior portions of the wing is not so well marked as in the living

[1] Except certain species which have very short wings.

species. In both, however, the posterior portion of the wing is the largest. To facilitate the description of the neuration, we will divide the wing into parts, as in the living species. The total length is 85 mm., and the breadth, near the middle of the wing, 32 mm. The upper marginal nerve (*a*) is a little curved towards the middle of the wing (Fig. 2*a*); the upper sub-marginal (*b*) is parallel to the marginal (*a*), but straighter, and at the broadest portion they are 6 mm. apart. The externo-median (*c*) is 1 mm. from the upper sub-marginal (*b*), and at the extremity of the wing it is distant 5 mm. from it. The median (*d*) follows the same direction as the preceding one, but it is more curved.

A branch formed by the union of the reticulations, and which becomes a true nerve, divides into two branches near the extremity of the wing. The interno-median (*e*) is one mm. from the median nervure, and at a distance of 13 mm. from the base of the wing it dichotomises; the upper branch, at 14 mm. from the margin of the wing, is divided into two branches. The second branch of the internal median, which is given off from the principal trunk at 14 mm. from the edge of the wing, separates into two branches, the upper one of which alone dichotomises. The lower sub-marginal (*f*), which is 2 mm. from the preceding one, divides into two branches, the upper one of which subdivides again into two. The anal nerve (*g*) is very short, and splits up almost immediately into two branches; then, at a distance of 7 mm. from the base of the wing, we see 14 straight and slender nerves, which alternately subdivide into two branches near the ventral margin. All these nerves are united by numerous straight and delicate reticulations.

The wings of the existing species of Phasmians are generally covered with colour-bands, either brown or blue, on a ground of a lighter hue; this was evidently the case in *Protophasma* also. We see, in fact, with the naked eye, darker bands which traverse the wings transversely to the general direction of the nerves. In the neuration and coloration of the wings, the fossil form resembles most nearly the *Phasma variegatum*, Stoll.

The habits of the Phasmians are but little known, but they are vegetable feeders, whereas the MANTIDÆ are carnivorous. These insects crawl sluggishly on plants, and feed upon the young shoots of resinous trees, their habits are generally solitary.

In the Carboniferous period we find evidence of the existence of numerous trees of the family Coniferæ (and Lycopodiaceæ), such as *Sigillaria, Calamodendron, Arthrophytis, Cordaites*, etc., all resinous trees suitable for *Protophasma.*

It is remarkable that the insects of the Carboniferous epoch appear to differ but little from those which exist at the present day; but it is not in France, nor even in Europe, that we must look for insects like those which existed at the epoch of the Coal-formation. It is in the hot regions of America, Asia, Africa, and Australia, that we find their homologues; and the Orthopter which we have just described adds another example in support of this assertion. All that we know of the Flora and Fauna of the Coal-period, proves to us that the Earth was covered with a sheet of water of little depth, from which numerous islands emerged, over which a luxuriant vegetation spread. There, in the water, lived the *Palæocypris* and the *Palæoniscus*, on the banks of the water, upon the *Sigillarias*, lived the Phasmidæ and Mantidæ, of which several species have been discovered. In the interior of these islands, in the earth formed of leaves, stems, and branches of plants, lived a great number of *Blattidæ*.

The knowledge we possess of the Carboniferous period, that is to say, of the plants and animals, proves to us that there was at this epoch a higher temperature and intense sunlight. The presence of these two insects supports this conclusion, since all the existing representatives of these groups live in the open sunlight in the hotter and more humid regions of the globe.

EXPLANATION OF PLATE IV.

Fig. 1. *Protophasma Dumasii*, Ch. Brong. *a*, head; *b*, antennæ; *c*, eye; *d*, palpi; *e*, prothorax; *ff*, first pair of legs; *gg*, elytra; *hh*, second pair of legs; *jj*, third pair of legs; *k*, abdomen, restored; *n*, wing folded on itself; *m*, wing border of the second pair, restored; *rr*, wings of second pair.
,, 2. Wing of the second pair, restored (the letters are explained at p. 101).
,, 3. Part of Fig. 2, twice natural size. Fig. 4. Elytron.
,, 5. Wing and Elytron of *Diura Japetus*, Gray. *a*, upper portion of wing with straight nerves; *b*, lower portion with nerves radiating from base of wing; *c*, elytron.
,, 6. Head of *P. Dumasii*, twice natural size; *a*, prothorax; *b*, head; *d*, palpi; *e*, labrum; *f*, eye; *g*, mandibles; *h*, antennæ.
,, 7. Head of *Diura Japetus*, Gray. Fig. 8. Half of same, twice natural size.
,, 9. One of the third pair of legs of *P. Dumasii*, twice natural size.

II.—Post-Tertiary Geology of Cornwall.[1]

By W. A. E. Ussher, F.G.S.

Part II.—Pleistocene Period.

THE materials for a classification of the later Pleistocene deposits of Cornwall are so voluminous that it was found impossible to embody them in a single paper. Having submitted to the Geological Society a general classification with such notices of the deposits as seemed necessary to show the grounds whereon it was based, I purpose in the following paper to complete the notices of deposits. As an apology for the amount of compilation thus rendered necessary, I must plead the object of the papers, viz. to place in one view all that has been written on the subject, as references alone would entail more time and trouble in looking up than many readers would be disposed to concede.

The paper is divided into the following sections:—

1. Oldest superficial deposits; 2. (*a*) Boulder Gravels, (*b*) Raised Beaches, and (*c*) "Head." 3. Submerged Forests and Stream-Tin Gravels. 4. Recent Marine and Blown Sands.

Oldest Superficial Deposits.—From their isolated positions, and evident relations to an entirely different surface configuration, the gravels of Crousa Down and Crowan, and the sands and clays of St.

[1] Continued from the February Number, p. 81.

Agnes, must be regarded as the earliest traces of superficial deposits as yet observed in Cornwall.

Gravels of Crousa Down and Crowan.—On Crousa Downs, Lizard District, a patch of rounded and subangular quartz gravel "occupies an area of about half a square mile at a height of about 360 feet above the sea" (Report on Geol. Corn. and Dev. p. 396).

The Rev. E. Budge (Trans. R. G. S. Corn. vol. vi. pp. 1 and 91) describes the deposits, generally, as extended layers of fine yellow gravel, with a quantity of quartz pebbles, exposed in pits 10 to 12 feet deep in places, near the road leading to Coverack. The character of the sections is given thus—Black peaty soil containing small angular quartz stones about 6 inches thick, upon layers of fine and very coarse gravel alternating in no very determinate order, containing quartz pebbles of very irregular form, some as large as a man's head, but for the most part not exceeding 2 to 3 inches in length. The Crousa Down gravel rests on Diallage rocks.

A similar occurrence was noticed by Mr. Tyack (62nd Ann. R. Geol. Soc. Corn. p. 176, etc.) at Blue Pool in Crowan. The pebbles covered an area of 800 yards from north to south, and 500 from E. to W. They are scattered over the surface, are well worn, and vary in size from large boulders to the dimensions of hazel nuts. The gravel is 400 feet above the sea, it rests on yellow clay. As at Crousa Down the quartz is such as would be furnished by veins in the Killas, the pebbles of schorl being very few, and the occasional granite fragments angular; yet the Killas districts near Crowan are at a much lower elevation than the granite on which the pebbles are found.

These quartz gravels appear to have been derived from quartziferous Killas, either by direct transport of aqueous agencies sufficiently protracted in their operation to allow of the comminution of the slaty matter, or indirectly by the disintegration and redeposition of a quartz conglomerate rock of Palæozoic age. Referring to the derivation of the Crousa Down Gravel, the Rev. E. Budge illustrates the prevalence of quartz veins in the Killas to the north by citing the occurrence of masses of quartz in the slates near Nare Point, whence they can be traced for some miles along the line of strike; and of a quartz vein 10 feet wide on the south-west of Carne, in St. Anthony parish.

Between the Loo Pool and Marazion, on the top of the cliffs, near Trewavas Head, small flint and quartz pebbles occur in the soil, and do not appear to extend more than a few paces inland. As their height above the sea and the adjacent configuration preclude the possibility of their being the relics of a raised beach, I am forced to conclude that they are either traces of gravels somewhat similarly situated to those of Crousa Down and Crowan, or that during exceptionally severe gales some of the smaller pebbles of the beach below had been from time to time carried upward in the spray and landed on the top of the cliff.

Deposits of St. Agnes.—(Report, etc., p. 258). De la Beche was disposed to regard the sands and clays which nearly encircle the higher parts of St. Agnes Beacon as "the remnant of some supracretaceous deposit." "They occur at an elevation of between 300 and 400 feet above the level of the sea, resting upon the slates of the hill, and partly also on a small portion of the granite rock which there occurs; the granitic rock and slates being traversed by several tin lodes." "This isolated deposit has not hitherto been found to contain organic remains, with the exception of some traces of plants that have the appearance of Fucoids."

The following sections are given by De la Beche (Report, p. 259); Hawkins (Trans. Roy. Geol. Soc. Corn., vol. iv. p. 135, etc.); Henwood (*op. cit.* vol. v.); respectively—on the North-east of the Beacon. Numbers affixed for reference:

(1) Head of rubble from hill above or Cobb	3ft.	0in.
Yellow sand	2ft.	0in.
Brownish sand with numerous planes dipping at 45° (apparently bedding)	11ft.	0in.
Light-coloured mining clay	2ft.	0in.
Blue clay	9ft.	0in.
Yellow sand	4ft.	0in.
White sand	4ft.	0in.
Yellow sand	3ft.	0in.
Pebbles resting upon an uneven surface of slate—thickness variable.		

(2) Near Trevaunance—

Yellow Cobb with Killas rubble		
Fire clay	2ft.	0in.
Clay and sand	3ft.	0in.
Fine white gritty sand—depth not ascertained.		

(3) Half a mile from the Beacon—

Surface 383 feet above high water.

Clay	2ft.	0in.
Yellow sand, 7 feet below the surface	8ft.	0in.

The overburden not mentioned would seem to be 5 feet thick.

The following sections given by Messrs. Kitto and Davies lie toward the North-east of the Beacon (Trans. R. G. Soc. Corn., vol. ix.):

(4) Near the outer margin of the deposit—

Head	5ft.	0in.
Yellow sand	2ft.	0in.
Red sand	2ft.	0in.
White sand	4ft.	0in.

Pebbles in sand not gone through.

Sections near the above on N.W. and S.W.

(5) On N.W.—Head	6ft.	0in.
Clay with a few pebbles	3ft.	0in.
Sand	12ft.	0in.
Sandstone	2ft.	0in.
Sand with pebbles not gone through.		

(6) On S.W.—Very sandy overburden, with numerous quartz pebbles from the size of a marble to that of a walnut, beneath which clay only is raised varying from 6 to 12 feet in thickness.

On the inner margin of the deposit to the west of the above, "mining operations in 1865 exposed a cliff facing North, 16 feet in height, and 15 feet below the surface," nearly perpendicular, "smoothed and polished" and worn "into caves and hollows." An adit cut through to the sand on the other side proved this to have been in all probability a projection from a main cliff face, which old miners state to occur facing eastward for some distance to the southward, and to be worn into numerous hollows. The sand in this part of the deposit "contained very large pebbles and boulders and angular" stones.

Compare the section given by De la Beche (*op. cit.*) with the following by Hawkins on the North side of the Beacon (*op. cit.*), and by Henwood, locality not specified (*op. cit.*):

(7)	Yellow Cobb with rubble of Killas stones	2ft. 6in.
	Brown sand with sedimentary divisions dipping S. at 45°...	9ft. 0in.
	White Clay	4in. to 5in.
	Brown and bluish-grey clay (with a slight admixture of carbonaceous matter)	9ft. or 10ft. 0in.
	Gritty sand	6ft. or 7ft. 0in.
(8)	Loose stones and earth, up to	6ft. or 8ft. 0in.
	Pink, yellowish, and brownish sand, in layers dipping southward.	2ft. to 10ft. 0in.
	(In the lower portions small ferruginous crusts and masses of conglomerate in a sand or clayey matrix are sometimes found in various pits.)	
	Stiff blue clay	1ft. to 1ft. 6in.
	Milk-white sand occasionally clayey in the upper part.	
	Bed of pebbles in which stream-tin is said occasionally to occur.	

The following section on the North of the Beacon is given by Dr. Boase (Trans. R. Geol. Soc. Corn. vol. iv. p. 296):

(9)	1. Subsoil—earth with angular stones	1ft. to 2ft. 0in.
	2. Yellow and white sand, with minute particles of schorl	
	3. Dark ochreous-coloured sand, with a minute quantity of clay between the grains	2ft. 0in.
	4. Soft and greasy, tough, adhesive blue clay, with an oily rancid smell, as if from impregnation of animal matter	1ft. 0in.
	5. Clay (called Furnace clay), white and plastic, emitting an argillaceous odour	3ft. 0in.
	6. Sand, nearly pure white...	7ft. 0in.
	7. Loose rubbly layer, like (1), said to rest on solid rock.	

(10) Quoted by Mr. Henwood (*op. cit.*) from the Mining Review, paper by Mr. Thomas:—Section on the North of the Beacon, half a mile from it, near Wheal Kind. Surface 383 feet above high water. Eight feet sunk in white sand (7 feet below the surface).

(11) Mr. Henwood quotes (*op. cit.*) the following:—N.W. from the Beacon. Surface at 377 feet above high water. Sand met with at 3 feet below the surface; 15 feet sunk through yellow sand.

(12) Messrs. Kitto and Davies give the following section to N.W. of the Beacon:

Soil and Head	4ft. 0in.
Blue fire clay (coarse, through admixture of sand)	7ft. 0in.
Candle clay, adhesive and very tough	2ft. 0in.
Sand resting on Killas	5ft. 0in.

(13) Mr. Hawkins (*op. cit.*) gives the following section on the East of the Beacon:

Depth of the deposit, 24 feet in all.

Yellow Cobb under vegetable mould	2ft. to 3ft. 0in.
Yellow sand	3ft. to 4ft. 0in.
Mining clay	1ft. 2in.
White sand	$4\frac{1}{2}$ft. to 5ft. 0in.
A few flattish pebbles in black mud (local name)	2ft. to 3ft. 0in.

(14) Messrs. Kitto and Davies give the following section on the east of the Beacon (*op. cit.*) :

Head	6ft.	0in.
White candle clay	3ft.	0in.
Gravel	1ft.	0in.
White candle clay	2ft.	6in.
Yellow and whitish sand not gone through.		

The following sections were taken in the isolated part of the deposit on granite to the West of the Beacon :

(15) Hawkins (*op. cit.*)—

Yellow Cobb	4ft.	0in.
Clay	6ft.	0in.
Puddle sand (local name)...	2ft. to 3ft.	0in.

(16) Henwood, quoted from Mining Review (*op. cit.*):—Surface 418 feet above high water. Sand met with at 9 feet below the surface; 12 feet sunk through yellow sand of a lighter tint at the base.

(17) Messrs. Kitto and Davies (*op. cit.*) :

Head	9ft.	0in.
Candle clay	20ft.	0in.
Dark red sand	0ft.	3in.
Yellowish sand	2ft.	0in.
Gravel, pebbles, boulders, and sand resting on granite	3ft.	0in.
	34ft	3in.

I observed four pits, all in the main deposit, and lying to the northward of the Beacon, varying from seven to eleven feet in depth ; the very impersistent nature of the clay and of the colours in the sands was very noticeable.

From the map and sections accompanying the paper by Messrs. Kitto and Davies (*op. cit.*), it will be seen—that the clays are in no place coextensive with the sands, although in parts their boundary approaches very near to the limits of the deposit; that they are the thickest in the isolated patch on the granite (17), which lies in a basin ; that the coarse detritus is of exceptionally local character in the different sections, tin stone pebbles being confined to the immediate vicinity of lodes. The appearances of bedding in the sand, and the relative positions of the sands and clays in sections (1), (7), and (8), are indications of a continuity of deposit, which the variability of the other sections given shows to be abnormal. The occurrence of quartz pebbles in exceptionally sandy overburden (section 6), is worthy of note, and suggests the former overspread of gravelly detritus, similar to the gravels of Crousa Down and Crowan.

The Head, as far as I observed it, consists of brown loam, with angular fragments of local rocks derived from the hill above, resembling, according to Messrs. Kitto and Davies, "The soil and subsoil found upon the Killas of Cornwall, except that it is somewhat sandy in parts and occasionally contains washed pebbles." This Head, Overburden, or Cobb, is of like nature, and probably roughly contemporaneous with the accumulations of stony loam on the coasts hereafter to be noticed. The preservation of the deposits in their present form is probably largely due to this protecting envelope of talus shed from the adjacent Beacon hill, which exceeds 600 feet in height.

From such local materials as the granite on the west of the Beacon, the Elvan Course to the north of it, and the Killas, the sands and clays seem to have been formed.

The position of the deposits with reference to the present coasts, and to the high land of the Beacon, and the cliff-like sections and waterworn hollows noticed in some parts, would seem, "as De la Beche suggests," to justify a marine origin, but with them "the resemblance to the raised beaches appears to terminate" (Report, page 258.) The interchangeable characters of the sands and clays are more in accordance with the irregular deposition of a stream, subject to fluctuations attendant on meteorological changes, than with the more uniform sorting action of a coast-fringing sea. The very local character of the basement gravels is also against the admission of a marine origin. As an entirely new system of drainage has been moulded since the deposits were thrown down, proximity to the present coast-line is no argument in favour of marine origin or former proximity to the sea.

Fluviatile agencies, which have produced similar effects in wearing the surface of the shelf in stream-tin sections, coupled with the weathering and water-wear of a vertical face, slickenside, or joint, might, in the absence of further evidence, explain the phenomena of the smoothed surfaces, water-worn hollows, and old cliff face mentioned by Messrs. Kitto and Davies. Had such action prevailed for a long period in an old line of drainage down which the coarser detritus had been swept, the damming up of the old stream course and selection of a new one above the present site of the deposits, would tend to the formation of a lake in whose quiet waters the finer debris of the adjacent land borne down by rills and streamlets would have been filtered, and have settled down in the form of sand and clay.

The isolated positions of the deposits of Crousa Down, Crowan, and St. Agnes, afford no clue as to their relative ages. Yet this isolation justifies me in classifying them together as the oldest superficial deposits as yet noticed in Cornwall. An entire bouleversement of the levels of their respective districts has taken place since their formation, and all traces of synchronous deposition have been swept away in the elaboration of the present drainage system. As they can only be regarded as relics of much more widespread deposits, the possibility presents itself that we may have in them the traces, *in situ*, or re-distributed, of Tertiary or even late Cretaceous deposits, presenting a different aspect to that in other areas through dependence on local sources of supply. During the vast period that intervened between the Culm-measure rocks and the Pleistocene Age, it is unreasonable to argue from the absence of deposits of intermediate age that Cornwall was never invaded by Secondary or Tertiary seas.

On the Occurrence of Flints in Cornwall.—De la Beche (Report,

p. 429) commented on the abundance of rolled Chalk flints in the recent as well as the Raised beaches on the Cornish coast; he suggested the existence of a race making use of flint implements prior to the raising of the beaches, and that these flints in transport from the localities whence they were derived, might have been dropped, and, in unlading, have been lost and rolled with the beach pebbles. This theory may be dismissed as untenable both on account of the absence, in inland localities, of relics of such a race as that invoked, and on account of the number of natural flints and the absence of signs of manufacture.

Mr. Peach notices (T.R.G.S. Corn. vol. v. p. 55) the abundance of flints in some of the coves at Gorran, and suggests their derivation from the Chalk of "No Rest," off the Dodman Point, "a name given to some submarine rocks by the fishermen, owing to their trawls becoming hitched in the rough ground."

It is scarcely credible that such observers as De la Beche, Borlase, Boase, Carne, Henwood, etc., could have failed to notice the existence of Cretaceous rocks off the Cornish coast, and, if known to them, they would certainly have commented upon them. Therefore, in the absence of further particulars, it is safer to regard the "Chalk of No Rest" as a local epithet without any geological significance.

De la Beche, quoting Borlase (Nat. Hist. p. 106, in Report, p. 646), says: "In the low lands of the parish of Ludgvan, in a place called Vorlas, there is a bed of clay, about three feet under the grass, in which numbers of chalk flints are found, with pebbles of quartz and some shingle, with pieces of angular slate." I was unable to find the locality indicated, the present rector of Ludgvan being ignorant of the name. Thinking, however, that Vorlas might be a misprint for Crowlas, a small village on the flats near Ludgvan, I made inquiries there, but failed to elicit any information respecting the occurrence of flints in the neighbourhood.

Mr. Henwood (Journ. R. Inst. Corn. vol. iv. p. 214) mentioned the occurrence of flints of considerable size in the tin ground at Lower Creamy, a part of Red Moor, in Lanlivery, N. of St. Austell. He also stated that a few flints have been very rarely found in a peat bed, containing remains of furze, alder, oak, and hazel, in the stream works of Pendelow, as shown in 1873 (*op. cit.* p. 213).

Mr. Higgs (T. R. G. S. Corn. vol. vii. p. 449) gives a short notice of the discovery of a substance resembling a chalk flint in a cavity in a lode in Balleswhidden Mine.

If the above are Cretaceous flints, and not fragments of slate or fine grit, to which contact with igneous matter had imparted a cherty character, they would seem to indicate the destruction of Cretaceous material, or of deposits of a later date, resulting in part from the waste of Chalk.

Mr. A. Smith (T. R. G. S. Corn. vol. vii. p. 343) mentioned the occurrence of comparatively unworn chalk flints, and fragments of Greensand rock more worn, on Castle Down, in Tresco, one of the Scilly Group.

Mr. Spence Bate (Trans. Dev. Assoc. for 1866) alludes to the occurrence of flints in moorland around Dosmare Pool, Curza (? Crousa) Down, on the top of Maen rock, at Constantine, and on Trevose Head.

The flints occurring in the Raised Beaches will be noticed in the section devoted to the latter further on.

As the present drift of shingle from W. to E. is the reverse of that which the presence of chalk flints in the recent beaches would lead us to expect, we may conclude that they were obtained by the destruction of the raised beaches, and explain their occurrence in the latter by either of the following hypotheses: first, that the set of the wind-waves during the formation of the Raised Beaches was the reverse of the present, as Mr. Godwin-Austen suggests (Q.J.G.S. vol. vi. p. 87); or, secondly, that during the Pliocene or part of the Pleistocene Period, prior to the formation of the raised beaches, the land stood at a much greater elevation, and the English Channel valley as dry land "served to connect the British Islands with France, etc." (Godwin-Austen, *op. cit.*); that a large part of its area was drained by rivers and streams flowing westward, and carrying Cretaceous and other easterly derived detritus in that direction, which detritus, on the submergence of the valley, was incorporated by the Pleistocene sea in the beaches then successively marking its advance, till the culmination of the subsidence at levels marked by the Raised Beaches.

Notes on Glacial Hypotheses.

Although the Glacial epoch has left no direct evidences of its changes in Devon and Cornwall, it is scarcely possible that either county remained uninfluenced by them. The very fragmentary relics of deposits formed during the existence of a previous and very different configuration seems to call for some such powerful denuding agencies as torrential surface waters, consequent on the termination of rigorous conditions of climate.

The Rev. O. Fisher (Geol. Mag. 1873, Vol. X. p. 163) ascribes the reversal of laminæ in schorlaceous granite, in Carclaze Mine, to the passage of ice over them. But such phenomena, as I have elsewhere (Q J.G.S. 1878, vol. xxxiv. p. 49) endeavoured to show, furnish no proofs of ice-action in the South-west of England. Striæ or moutonnéed surfaces have not been detected in Devon or Cornwall. The grooved face of rock near Barlynen Abbey, North Devon, ascribed by Prof. Jukes to ice-action (Geol. Mag. Vol. IV. p. 41; *vide* Whitley, 32nd Ann. Rep. R. Inst. Corn.), is merely a voluted bedding plane, a structure not unfrequently met with in Devonian and Culm-measure rocks, and exhibited by some beds in an adjacent quarry.

If Cornwall was at any time subject to extreme glacial conditions, its highlands were not submerged during the Glacial epoch, nor were its borders invaded by a foreign ice-sheet; for traces of submergence would be found in the one case, and foreign ice-borne materials in the other. Positive evidences of local glaciation are also wanting, unless we regard the presence of large boulders at high levels, as the diallage blocks of Crousa Down for instance, as the unremovable *débris* of an old glacier system, and ascribe the presence of large boulders, at some distance from their parent rocks, in river gravels, to the relics of moraine, carried down to successively lower levels in the excavation or deepening of the present lines of drainage. However, if, as I agree with Mr. Godwin-Austen in thinking (*op. cit.*), the land stood at a much greater elevation during the Glacial epoch, a great and constant snowfall may have given rise to local glacier systems; and as the present area of the county would offer little more than the generative sources of the (imaginary) glaciers, all traces of pre-existent deposits and of moraine matter, except very large boulders, would be swept down by the flood waters of the succeeding period of subsidence to levels now submerged. But as all such glacial theories are purely hypothetical, it behoves one to fall back on the probability that Cornwall, during the Glacial epoch, stood at a much greater elevation, and that its highlands were crowned with constant snows, the melting of which during the succeeding amelioration, accompanied by subsidence, caused the liberation of great quantities of surface water with torrential power carrying off the pre-existing detritus to lower lands, now submerged.

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

I beg leave to correct the following errata in Part I. of my paper. On p. 33, line 40, *for* "10 to 20" *read* "10 to 12;" on p. 34, line 20, *for* "B.C. 400" *read* "B.C. 440," and *for* "εκσας" *read* "ἐουσας," also *for* "νησας" *read* "νησους;" and on p. 79, line 1, *for* "on" *read* "or."—W. A. E. U.

III.—On the Physical History of the English Lake District. With Notes on the Possible Subdivisions of the Skiddaw Slates.[1]

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

Post-Carboniferous Periods.

As the Carboniferous rocks form a framework around the Silurian mountain country, so do the Permian rocks for considerable distances lie as an outer flat and bevelled edge to the slightly raised Carboniferous frame, the edge indeed overlapping the frame itself along the west coast-line between St. Bee's Head and the Duddon Estuary.

It is not purposed to give a detailed description of any Post-Carboniferous formations lying outside the mountain district. The two thick Permian sandstones (the Penrith and St. Bees), separated by a set of shales and marls, are believed by some to indicate the conditions of an inland sea, and the formation in some parts of its English development to suggest cold or glacial conditions. However this may be, it seems more than probable that during the whole of the Permian Period the present Lake District was dry land, and undergoing that subaerial waste which, long continued, was to give

[1] Concluded from the February Number, p. 61.

rise to the present beautiful forms of mountain and valley. If the Permian were partly a cold period, then an early set of glaciers may have found their home among the early Cumbrian mountains, and any amount of ice-smoothing and polishing of the rocky surface then produced must, to a certain degree, have hindered the work of denudation for a long period afterwards. Indeed, it is more than likely that the very large amount of denudation produced by glacial means during a glacial period is more than counterbalanced by the retarded action of subaerial forces working upon a generally smoothed and rounded surface. In post-Permian times, when extensive north and south movements and dislocations occurred (as along the foot of Cross Fell range, and the Pennine Anticlinal), sympathetic movements may have taken place in the mountain nucleus, and very likely the majority of the N. and S. faults ranging through the Silurians, and frequently shifting the previously formed E. and W. ones, were produced at this period.

As we pass in review the periods succeeding the Permian, nothing more can be said with regard to the history of the Lake District than that in all probability the Cumbrian centre remained an area of dry land, more or less lofty, though slowly being eaten down and into by the forces of denudation. From the mountains as they then existed one could have looked northwards and southwards into areas of water beneath which the New Red deposits were being formed. Subsequently the Liassic sea with its marine monsters probably skirted the mountain district at no great distance.

Onwards in time through the Jurassic Period, with its Australian-like climate, during which the Cumbrian mountains may have experienced many a storm of semi-tropic violence, through the long Cretaceous Epoch and Tertiary times must the District have been suffering wear and tear, at times doubtless nearly or quite united to the neighbouring high ground of the Pennine Range and of Wales. No wonder so much has been carried away by apparently weak subaerial powers of denudation, rather the wonder is that the mountains should have been preserved at all, instead of all being levelled to the sea. This will again be commented on in following pages, when the question of the numerical equivalents of periods will be discussed. That the District experienced many vicissitudes of climate throughout this enormous length of time seems certain—now temperate, now semi-tropic, and now again probably glacial, and the last marked geological change which it underwent was during the so-called Glacial Period proper.

Glacial Period.

This period having been treated of in full, as regards the Lake District, in my former Papers, and in much detail in the Survey Memoir, chap. xiii., nothing but a mere necessary outline will be now given.

The glacial phenomena of the district are as follows:—Till, mainly the product of a confluent glacier-sheet. Drift gravel, and stratified sand and gravel, often occurring in the form of eskers, due principally to marine action. Boulders carried far from the parent-rock by glacier-ice at one time, and floating-ice at another. Glacial scratches partly produced by a confluent glacier-sheet, partly by small separate glaciers; also occasionally made by floating-ice during the period of submergence. Moraines left by an early set of glaciers, much modified by subsequent aqueous action; and more perfect moraines left by the most recent local glaciers. Many years study of these phenomena has led me to draw the following general conclusions, which I take in part from my Survey Memoir, p. 97:

"At the commencement of the cold period small glaciers occupied the heads of the various valleys, and, as the cold continued and increased, they became larger and larger, until, in many cases, they united, overlapping the lower ridges parting valley from valley, and forming one great confluent ice-sheet, the movement of which was determined to the north and to the south, or east and west—as the case might be, in different parts of the district—by the main water-parting lines. A great quantity of rocky débris was moved onwards and left scattered over the country, partly by the first formed moraines being pushed forward, and partly by the ice overriding the same and dragging on and triturating the fragments beneath it. In this way the Till was formed, sometimes left in rock-sheltered upland hollows, but most largely deposited on the lower and less inclined ground.

"Whether this first land-glaciation was interrupted by one or more mild periods, the deposits in this district do not prove. As the final close of this epoch of intense glaciation drew on, moraines were left by the retreating glaciers plentifully scattered in every valley, but the glacial streams and rivers must have made much havoc amongst them, cutting them up and bearing away their material to lower levels.

"Then, when the cold had disappeared, began a submergence of the district to a very considerable extent. As the land sank, the old moraine material was sifted, sorted, and partly rounded. At the ends of some of the fiords or straits, sand-bars were formed; but, as there was no floating-ice during the earlier stages of submergence, these sand and gravel deposits enclosed no large boulders. The district became gradually converted into an archipelago, and currents circulated among the islands. When depression had gone on to the amount of 1,000 feet or less, the cold returned and ice-rafts bore blocks from one part to another.[1] In many cases the direction in which currents swept the floating-ice was the same as that of the old glaciers, and thus boulders were transported along the same course at different periods and by different means. Sometimes, however, or at certain parts, marine currents bore floating ice, with its boulders, in directions opposed to, or much at variance with, the old glacier courses. Thus, when the land stood about 1,200 feet lower than at present, a current, sweeping the north-western out-

[1] For maps showing probable form of land at different stages of submergence, see papers by the author on "Lake District Glaciation," *Quart. Journ. Geol. Soc.*, vol. xxix. p. 422, and vol. xxxi. p. 152.

skirts of the district, carried boulders from Sale Fell southwards on to Broom Fell. Not until the submergence reached over 1,500 feet was there any *direct* communication between the northern and southern halves of the Lake District, *except* by the straits of Dunmail Raise. Under such conditions a current very probably ran through those straits from south to north, turning mainly to the east on reaching Keswick Vale, though probably sending a branch off to the west; while other currents may have set through the straits between Skiddaw and Blencathra. The case mentioned of an ash boulder at the upper sources of the Caldew would seem to point to a current having *at one time* passed from south to north, *up* the Glenderaterra Valley and *down* through that of the Caldew. The block could not have reached its present situation from any of the volcanic deposits lying north of Carrock and Comb Height, and is scarcely likely to have come from the very limited *ash* exposures of Eycott Hill, to the south-east of the Caldew at Mosedale. It is not likely that this boulder could have been transported by glacier-ice or any form of ice-sheet, because it is in the very midst of lofty mountains which would have produced sufficient ice to have filled the valleys between them and kept out any ice-sheet foreign to this group. Hence, I am inclined to consider this case as a *proof* of submergence to the height of at least 1,300 feet, and of the existence of marine currents passing through the Skiddaw mountain group.

"The submergence continued until the land must have sunk more than 2,000 feet below its present level, as the position of boulders in many parts of the district seem to show, and notably those on Starling Dodd (see page 93, also Quart. Journ. Geol. Soc. vol. xxix. p. 437, and vol. xxx. p. 96). Then the whole district was represented merely by scattered islands clad in snow and ice, each a little nursery of icebergs.

"As the land was re-elevated, the glaciers crept down to the level of the sea, sometimes forming moraines just at the sea-margin, as was the case beneath Wolf Crag, Matterdale Common, when the land stood 1,400 feet below its present level. During all this time numerous boulders were let fall upon the early-formed mounds of sand and gravel, and as the sea shallowed, more of such mounds were deposited, now, however, frequently *containing* ice-borne blocks.

"Finally, when the land had regained its former height above the sea, glaciers still lingered in the recesses of the mountains, but this second set of glaciers at no time equalled the first in size. Some, in Borrowdale, were sufficiently large to creep down probably as far as Rosthwaite, and the more or less perfect moraines in every upland valley remain as the last traces of the Glacial Period.

"I think too that the immediate cause of the numerous lake-hollows, *many* of which are now completely filled with stream-borne detritus, was the onward movement of the glacier-ice when at its thickest, as suggested by Professor Ramsay's theory; for not only are these lake-basins extremely shallow when compared with the heights of the mountains and the thickness of the former ice-sheet, but in most cases the agreement is remarkable between the spots at which the greatest depth of water occurs and those points where, from the confluence of several ice-streams or from a narrowing of the valley, the onward pressure of the ice must have been greatest.[1]

"I have sometimes been asked whether the glaciation described in my papers on this district was not wholly belonging to the close of the Glacial Period, and whether previously the whole mountain district had not been overridden by a great ice-sheet from the north ? To this I answer that, so far as I am able to speak, there is *no* evidence in the district of such a mountain- and valley-ignoring sheet, and not *one* boulder of foreign northern rocks to be found *among* the mountains. Therefore the burden of proof lies with those who advocate this theory."

Post-Glacial Period.

With times subsequent to the Glacial Period we have here but little to do, though a few remarks may not be out of place.

I have often been struck with the scarcity of delicately poised perched boulders, and cannot but think that this may be partly due to shocks of earthquake in post-Glacial times, of sufficient severity to dislodge any such. The country is so thoroughly glaciated, that their absence is all the more conspicuous. But I fancy there are also other indications of earth-movements. There are several cases of fissuring upon mountain summits, and even of fissures *crossing* mountain ridges, which would appear to be the work of earth-movements more general than the slips so often occurring upon mountain slopes. Thus, on the summit of the Screes Mountain, and Kirk Fell, Wastdale ; upon and distinctly *crossing* the narrow ridge of High Stile, between Buttermere and Ennerdale : at Rosthwaite Cam, Borrowdale, and Helm Crag, Grasmere, are instances of fissures, many of them deep, long, and more or less parallel to one another. In some of these cases there is no appearance of slipping upon the mountain flanks, and I cannot but think that at least some of them are the result of the passage of earthquake waves.

Since the close of the Glacial Period, the atmospheric denuding agents have been much occupied over many areas in the work of clearing away glacial *débris*, such as once again opening out valleys partly choked by glacial drift—example, the valley between Threlkeld and Keswick. In other parts the denuding agents have had even harder work in roughening the ice-smoothed surface, and one may confidently say that the general contour of the country as we now see it can be but very little different from that which prevailed immediately anterior to the Glacial period.

"Stone implements of two kinds have been found in the mountain district; some are of the smooth and polished neolithic type similar to the stone axes from Ireland, figured in Sir J. Lubbock's *Pre-Historic Times*, at page 88 (2nd edit.) ; others are generally longer, more narrow in proportion to their length, and have a roughly

[1] See papers by the author.

chipped surface. One of the latter kind was found near the so-called Druid's Circle, Keswick, and another by the side of Loughrigg Tarn. The latter is 11 ins. long, $3\frac{1}{4}$ ins. broad, and 2 ins. deep; two beautiful photographs, giving a front and side view of this splendid specimen, have been presented to the Keswick Museum by Wheatley Balme, Esq.; the side view at once indicates the end used as a handle, the presence of which would seem to show that this was not merely an unfinished implement of the polished class, but was used in its present chipped form; and, indeed, the general shape of the two kinds is tolerably distinct. Several of these old stone implements of the district, and others of bronze, may be seen in the Keswick Museum.[1]

"These celts are mostly formed of the highly altered, felstone-like or flinty ash, which occurs so plentifully about Scafell. Rude stone circles, and many remains of what appear to be stone pit-dwellings occur (?).[2] The lakes, although examined in some cases at a very low state of the water, have not yet yielded any relics of ancient pile-dwellings. In later times the Roman occupation left its traces in roads over lofty mountains, and scattered camps and settlements."[3]

Part II.—Chronology of the Lake District.

I wish now to make an experiment, namely, to try whether, by using the most reliable estimates yet made, (1) upon the rate of deposition, (2) upon the rate of denudation, it be possible to draw up a Chronology of the Lake District to place beside the ascertained facts of History. I am sensible how uncertain are many of the data, yet it is well for the geologist occasionally to take stock of *time*, so far as he is able—that element in which he deals oftentimes so freely, and at times even recklessly.

For my purpose I shall avail myself of my friend Mr. Lloyd Morgan's article upon "Geological Time" (Geological Magazine, 1878, p. 199), in which he has conveniently brought together the estimates of various eminent geologists as to rates of deposition and denudation.

Skiddaw Slate Period.—The deposits of this period, if not altogether deltaic, are not far removed in character from such. We have seen how large a proportion of them must have been laid down in shallow water. If then we take $\frac{1}{10}$ of an inch per annum as the average rate of deposition for deltaic sediments, and allow that

[1] I may here mention that this museum has been started with the hope of illustrating, as completely as possible, the Natural History of the district. Any help from naturalists visiting the country would be most gladly received, as the working resources are somewhat limited.

[2] I have placed in the Keswick Museum of Local Natural History a map of the District on the 1-inch scale, upon which are marked in different colours and patterns (1) all pre-historic remains, (2) Roman remains, (3) camps, etc., of uncertain age; and a detailed account of these will be found in a paper entitled "Notes on Archæological Remains in the Lake District," published in the Transactions of the Cumberland and Westmoreland Antiquarian and Archæological Society, 1878, p. 241.

[3] Geology of the Northern Parts of the English Lake District, by the Author.

distance from the actual area of a delta means a *decreased* rate of deposition, we may assume perhaps that the 10,000 feet of Skiddaw Slates were laid down at the rate of $\frac{1}{50}$ of an inch per annum, and this would give a period of six million years for the formation of the whole series. If, however, we take the rate at $\frac{1}{10}$ instead of $\frac{1}{50}$, the period is reduced to less than $1\frac{1}{2}$ million.

Volcanic Period.—No reliable estimate can be made of the rate of deposition of volcanic material. The length of the periods of repose between successive eruptions appears to be very variable. In this particular case, however, there is nothing to lead one to suppose that the eruptions were not tolerably continuous. There seem to be no great breaks in the series, and, for aught we know to the contrary, the whole thickness of some 12,000 feet may represent continuous and violent action. Hence I am inclined to put the rate of accumulation at not less than $\frac{1}{10}$ of an inch per annum, which gives a period of $1\frac{1}{2}$ million years. If we take $\frac{1}{5}$ as the rate—as Mr. Morgan has assumed in the case of Etna—the length of the whole period is reduced to 720,000 years. The gap between this and the next period might be put down at $\frac{1}{2}$ a million of years, perhaps some 500 feet having been removed at the rate of 1 foot in every thousand years, the denudation acting upon a sinking area.

Upper Silurians of Lake District.—The same remarks may be made on this series of sedimentary deposits as on those of the Skiddaw Slates. Although in great part they must have been formed in tolerably shallow water, yet might the deposition have gone on more or less outside the limits of a delta proper. Taking therefore the rate of deposition at $\frac{1}{30}$ of an inch per annum, a thickness of some 14,000 feet of beds may represent a period of about $8\frac{1}{2}$ million years.

Old Red Period.—Here we have not facts of deposition to calculate from in this district, but those of denudation. What length of time must have elapsed between the close of the Upper Silurian and the commencement of the Carboniferous, to allow of the removal of probably more than 20,000 feet of rock, so that the Mell Fell conglomerate could be deposited transgressively upon both Volcanic Rocks and Skiddaw Slates? The length of time must have been great indeed, for the extensive denudation necessitates also a great amount of continued elevation to allow of the deeply buried strata coming within the range of the denuding powers. A planing action is required to cut off the rising land along the main axis of upheaval; and the sea alone can supply us with this. The work, in fact, would be most efficiently done if we could suppose the elevation to be going on but very little faster than the sea could gnaw and eat the land down. Now are we warranted in assuming that the rate of denudation under such circumstances would be greater than in the case of a tract of country lowered mainly by subaerial agencies? I think we are. Prof. Geikie has calculated that the area of country drained by the Mississippi is being lowered at the rate of one foot in 6000 years, while that drained by the Po is being lowered at one foot in 729 years; the Ganges, Hoang Ho, Rhine, Danube, and Nith are each lowering their basins at rates intermediate between these extremes. We might, I think, assume that the sea acting as a great planing agent, aided by the atmospheric forces working on those parts well above water, might denude at the rate of one foot in 750 years, the elevation along the main axis going on at about the same, or but little more than the same rate. But even this comparatively high rate of denudation would require 15 millions of years to do the work which was effected.

There can be no doubt that the Old Red Period (*i.e.* all the time between the close of the Upper Silurian and the commencement of the Carboniferous, as shown by the deposition of the basement beds) was one of great duration. Palæontological facts demand a great length of time, and the facts of physical geology, not only in England, but markedly in Scotland, demand the same. Still, it is with some little compunction that one draws on Time's bank as large a draft as 15 million years.

Carboniferous Period.—A large proportion of the thickness of Carboniferous rocks is undoubtedly deltaic in character. If we allow the British Carboniferous to have a thickness of some 20,000 feet at the outside, then taking 12,000 feet as delta deposits, and 8000 feet as limestone and extra-deltaic, we arrive at the following conclusion:—

12,000 feet	at rate of	$\frac{1}{10}$	of an inch	per annum	=1,440,000	years
8,000 feet	,,	$\frac{1}{50}$	,,	,,	=4,800,000	,,
100 feet of Coal	,,	$\frac{1}{100}$	,,	,,	= 120,000	,,
					6,360,000	years,

or, in round numbers, we will say $6\frac{1}{2}$ million years. If the whole thickness be taken at the rate of $\frac{1}{50}$ of an inch per annum, the period indicated is 12 million years.

Post-Carboniferous Periods.—In England the various Post-Carboniferous formations do not amount in total thickness to more than 20,000 feet; but when we consider the large development of some of these formations abroad—example, the Eocene and Miocene—it is necessary in any calculations of total length of time to make a greater estimate than 20,000 feet. Accordingly I will take 40,000 feet—almost certainly an over-estimate—of rock deposited at the uniform rate of $\frac{1}{50}$ of an inch per annum. This represents a period of 24 million years.

Glacial Period.—For this last episode of geological history it is difficult to find data either of deposition or denudation to go upon. According to Mr. Croll's theory, the epoch commenced some 250,000 years ago, and ended about 80,000 years back. I have already stated that I believe there is evidence in the Lake District of a submergence to the amount of 2,000 feet, and Professor Ramsay long since stated that he believed there was like evidence in Wales. But although I see no other way of accounting for the facts, yet do I fully acknowledge the difficulty of the supposition. I am supposing that the Lake District group of mountains, which for so many geologic ages were being elaborated under subaerial agencies, now within the last million of years sank deeply beneath the sea, and was re-elevated without, apparently, any long periods of rest, and therefore without having left upon it many well-marked lines of marine action. Moreover, supposing Mr. Croll's theory to be the right one as to the cause of the Glacial Period, and taking the time indicated by that theory, this submergence and re-elevation must have taken place in some 200,000 years. Now, from what we know of such movements at the present day, the rate of two feet per century would appear high, and this rate would allow of no halt. There might be plenty of time for the District first to become shrouded in confluent glacier-ice, and then to be depressed and re-elevated under changing climatal conditions ; but I must acknowledge that the submergence to such an amount is somewhat embarrassing.

Post-Glacial Period.—According to Mr. Croll, about 13 feet may have been removed from the general surface of the country since the close of the Glacial Period (*i.e.* in 80,000 years). I doubt very much whether, taken all round, more than six feet has been thus removed in the same period over the area of the Lake District mountains, and this would be at the rate of one foot in every 13,000 years. The ice-action is yet so evident over large tracts, that I question whether even this may not be too high an average. The Skiddaw Slate mountains with their greater softness may, however, more than make up for the unyielding nature of the hard ice-smoothed volcanic rocks.

General rate of subaerial denudation in the Lake District.—The low rate of denudation just now assumed for the period since the close of the Glacial may be partly put down as resulting from the polished state of the country, but that the general rate over so small a mountain district must have been low is, I think, very probable. If an accurate model of the Lake District be examined, it will be seen that more material has been removed in the formation of the valleys than has been left to form the mountains. The mountain district might, indeed, as well be described as a valley district, so close to one another are the several valleys, and so narrow the mountain *ridges* separating them.

The question then arises, at what average rate has denudation been carried on since Carboniferous times ? Is the amount of denudation effected ridiculously small for the amount of time supposed to have been spent upon it ? or the reverse ?

At the close of the Carboniferous Period we must, I think, believe the area under description to have been elevated as a more or less lofty table-land, constituting the rough-hewn block out of which such a valley-system as that we now see has been carved. The height of that table-land we cannot indeed accurately estimate, but it may well have been higher than the height of the highest mountains as they now stand. This is not, however, a necessity, for much denudation may have been effected, ere, in times long after the close of the Carboniferous, the base of the country, so to speak, had been raised to its highest level, or, in other words, ere the movement of elevation had finally ceased. Still, I think we may assume, without much affecting the result, that at the close of the Carboniferous Period, the Cumbrian nucleus was elevated to its greatest height as a table-land with slight ridges and furrows, the early promise of mountain and valley. Uniting the summits of the chief mountains by means of a plane, we restore some such plateau; but as it is certain that the denuding agents would lower the country *generally* as well as along certain lines of valley, we must place the original plateau at a higher level than any plane now joining the mountain tops. Now the highest mountain, Scafell Pikes, is a little above 3,200 feet in height, and there are several others over 3,000 feet. Might we not suppose that the original plateau stood at 300 to 500 feet higher than the present highest point? If so, and we can form an idea of the present mean level, we get the thickness of rock removed over the area of the district in the work of scenic elaboration. If we take the Keswick one-inch sheet, we find that of a list of 47 mountain summits in this sheet, there are 34 above 2000 feet in height, and 18 above 2,500 feet. Probably the mean level is not less than 1,500 feet, and not much greater than 1,800 feet. Hence, if we assume the height of the original plateau to have been 3,500 feet (which may very likely be under the mark), and the present mean level to be 1,500 feet, we have to account for the removal over the area in question of some 2,000 feet of rock by purely subaerial agents. It should be borne in mind that none of the rocks thus removed are calcareous to any degree, and therefore they are not readily soluble in water; still the wonder remains that, if the original plateau did not much exceed 300 feet above the present highest point, more has not been effected by denudation during that long period from the close of the Carboniferous to the present, for the actual amount denuded seems insignificant indeed in comparison with that removed from the same district during the Old Red Period. Still, the changed conditions may make all the difference; in the latter case—that of the Old Red—conditions the most favourable for denudation may have prevailed—land rising scarcely faster than the rate at which the sea could plane it down; while in the case of Post-Carboniferous ages, the conditions are those of a small tract of only moderately high ground containing no soluble rock material, and eaten down and into by subaerial agencies. If the basin of the Mississippi be lowered by such agencies one foot in every 6,000 years, are we likely to err much if we assume that this small mountain area was denuded at the rate of one foot in every 10,000 years? Calculating on this supposition, the 2,000 feet removed, in the formation of mountain and valley out of the rough-hewn block provided at the close of the Carboniferous epoch, would represent a period of some 20 million years. In our former calculation of the length of time represented by the formation of of 40,000 feet of Post-Carboniferous strata, we arrived at a period of 24 millions of years.

Summary. — The foregoing time-estimates may now be placed together in one column, and in parallel columns the rates of deposition or denudation which have been assumed.

CHRONOLOGICAL SUMMARY.

	Million of years.	Rate of Deposition.	Rate of Denudation.
Skiddaw Slate Period.....	6	$\frac{1}{50}$ in. per annum.	....
Volcanic Period	$1\frac{1}{2}$	$\frac{1}{10}$ in. per annum.	....
Possible Gap	$\frac{1}{2}$	....	1 ft. in 1,000 years.
Upper Silurian of Lake District	$8\frac{1}{2}$	$\frac{1}{50}$ in. per annum.	....
Old Red Period	15	....	1 ft. in 750 years.
Carboniferous Period	$6\frac{1}{2}$	12,000 ft. @ $\frac{1}{10}$ in. per ann. 8,500 ft. @ $\frac{1}{50}$ in. „	....
Post-Carboniferous Periods	24	$\frac{1}{50}$ in. per annum.	....
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The above result may, after all, in itself be of little value; but if it helps to make one realize the *respective* magnitude of the various operations which the Lake District has undergone in the course of its long history, one main purpose will have been served. Whether the Old Red Period was one of such duration as here indicated or not, its length, in respect to the other formations, is probably shown with some degree of truth. Whether 60 millions of years have elapsed since the beginning of the Skiddaw Slate Period or not, it is more than likely that the time which elapsed between the first laying of the foundations in the early Skiddaw Slate sea and that time when the roughly-hewn block of country was turned out at the close of the Carboniferous epoch, for the tracing of scenic details upon it, was greater than the time consumed in the actual formation of our present mountain and valley system by subaerial denudation.

PART III.—NOTES ON THE POSSIBLE SUBDIVISIONS OF THE SKIDDAW SLATES.

Introduction.—In making some observations upon the correlation of the Skiddaw Slates with the Silurian rocks of Wales, I wish to bear in mind the following axioms. (1). Physical evidence, such as character and thickness of deposits, can be taken as no *absolute* guide in the correlation of distinct groups of strata separated from one another by considerable distances. (2). A general sequence of similar deposits in two distinct but not widely separated areas may be held to indicate a succession of similar conditions prevailing at or *near* the same period of time. (3). The evidence of fossils as to the age of a deposit is generally trustworthy when it is grounded upon *assemblages* of life, and when corroborating evidence is to be gathered from the formations above and below. (4). In determining the age of a formation due weight should be given to both physical and palæontological evidence, but neither should be relied on exclusively.

Applying these axioms to the case of the Skiddaw Slates, I wish to see whether the palæontological dictum as to their Lower Llandeilo or Arenig age can be unhesitatingly supported.

First, I would remark that this name—indicating the supposed age and the equivalent in Wales—has been given to the whole thickness of some 10,000 feet. Second, that this opinion is founded almost entirely upon the presence of certain groups of Graptolites. Third, that Graptolites are notably capricious in their distribution—witness in the Lower Silurians of Scotland the immense thickness of non-graptolite bearing and unfossiliferous strata associated with the one or two black shale bands bearing Graptolites. Fourth, that in the Skiddaw Slate Series as a whole there are several alternations of deposits varying much in character—an upper black slate series, a marked grit or gritty series, again a black and irony series of slates, passing down into a great thickness of sandy and gritty beds. Fifth, that the majority of the Graptolites have been found in beds above the upper grit, but that they also occur in those below the grit, where the sediment seems to have been favourable for their existence; while there are a few cases apparently of their occurrence even among some of the flaggy beds of the lower sandy and gritty series. With these preliminary remarks, I will pass, first, to the consideration of physical evidence as to subdivisions and their possible equivalency to Welsh Lower Silurians.

Points of Physical Evidence.—I had been working for some years upon the Lake District rocks, when Prof. Ramsay called me into Wales to trace a base to the Arenig series marked by a thin grit. In carrying out this work, I was often struck by the *general* resemblance in sequence of the deposits both above and below the grit to that of a like series in Cumbria, and on returning to the Lake country examined more closely the characteristics of the various parts of the Skiddaw Slates. The resemblance in physical character between the Arenig grit of Wales and the upper grit of the Skiddaw Series is perfect. With one or two local exceptions, the Cumbrian upper grit is thicker than the Welsh Arenig, but both are made up of similar materials, both vary much in coarseness, though almost always presenting some coarse gritty or conglomeratic portion, and both are much traversed by quartz strings. The constancy of the Arenig grit in N. Wales, though often not exceeding 12 or 20 feet, is surprising, and the fact is at any rate worth recording that among strata of somewhat parallel age in Cumbria there occurs a like grit. Moreover, in Wales the Arenig slates above the grit soon become mixed with volcanic deposits, submarine volcanic ejecta, and in Cumberland we have in the northern or Skiddaw district a considerable thickness of black Graptolite-bearing slates succeeded by a Volcanic Series, and in the south-western part, at Lank Rigg and Latterbarrow, the same Volcanic Series lying directly upon the grit. (See also previous remarks on this subject, page 51.)

Turning to the beds below the grit, we have in Wales the iron-stained Tremadoc Slates underlaid by a great thickness of flaggy, sandy, and gritty beds, the Lingula Flags. In Cumbria there is a like physical sequence; beneath the grit come black iron-stained slates, often quite indistinguishable from the Tremadocs of North Wales, underlaid by a great but unknown thickness of flaggy, sandy, and gritty beds. If reference will be made to the Horizontal Section through the Skiddaw Slate Series, No. 2, page 54, the course of which is marked in the accompanying Sketch-map, the sequence and lie of these subdivisions will be clearly seen. The central range of high mountains along this section shows the lower sandy series in their fullest development, the *physical* equivalents—as it would appear from above—of the Lingula Flags; and the black slates *beneath* the grit at either end of the section (shaded more darkly)—physical equivalents of Tremadocs—come in as a faulted synclinal in the valley between Whiteside and Grasmoor, the latter mountain presenting a very exceptional example of a summit formed by an anticline.[1]

Referring to Horizontal Section No. 1, page 54, it will be seen that the grit of Great Cockup dips southwards under the mass of Skiddaw (see also Map), and only reappears in an anticlinal fold on the south side of that mountain. Thus, the area of Skiddaw and surrounding mountains is mostly made up of the slates above the grit, the physical equivalents—and in this case the palæontological equivalents also—of the Welsh Arenigs or Lower Llandeilo. In a set of rocks so highly contorted as are those of the Skiddaw Slates, taken as a whole, it is often impossible to detect and trace the faults; but if my reading of the district be at all correct, there must, I think, be some large N. and S. fault or series of faults separating the tract of Skiddaw, etc., from that W. and S.W. of Derwentwater and Bassenthwaite Lake. This I have indicated in the Sketch-Map. That there are many such N. and S. faults of great size is proved by the frequent shiftings of the grit west of Great Cockup. In Hor. Sect. No. 1, page 54, a large strike-fault throws down the Volcanic Series against beds far *below* the grit, and while this is very generally the case for many miles west of Carrock Fell, yet is there clear evidence at several points of the passage upwards into the Volcanic Series of the higher beds of the slates *above* the grit. To sum up the physical evidence : while fully acknowledging the frequent inconstancy of physical characters, there does seem to be in this case of Cumbria and Cambria, some 60 to 80 miles distant from one another, a striking sequence of similar deposits, such, indeed, as to lead me to infer, so far as physical evidence can do so, that in Cumbria we have the following groups represented which are more or less equivalent to those of Wales.

Arenig Slates—True Skiddaw Slates.
Arenig Grit.
Tremadoc Slates.
Lingula Flags.

It is impossible everywhere to define the limits of these groups, so contorted and faulted is the District; but that they exist as generally definable subdivisions I have myself no doubt. It would seem—as already called attention to in the Survey Memoir—that the lowest

[1] This may be well seen looking up on to Grasmoor End from Crummock Water. In Horizontal Section No. 2, the upper black slate should have been represented as *conformable* to the underlying grit of Elva Hill.

sandy series of beds so largely developed in Grasmoor and Whiteside, either thin eastwards or have their place taken by less sandy and more slaty deposits in this direction; this, combined with excessive faulting, and the difficulty in tracing the faults, owing to contortion and cleavage, makes it exceedingly hard to draw the actual boundaries of these groups in many places.

Points of Palæontological Evidence.—In assigning the whole thickness of the Skiddaw Slates to the Lower Llandeilo, and that mainly on the strength of the Graptolite fauna, Axiom (3) is distinctly transgressed in both its clauses, for the Graptolite family cannot be taken as a characteristic *assemblage* of life in general, and the formation above (the Volcanic Series) is unfossiliferous, while nothing is known of that below. Still, the group of Graptolites being such as is known to be characteristic of rocks of Lower Llandeilo age elsewhere, is evidence of considerable value, though not to be too exclusively relied on; but when the palæontologist says further that the whole of this Skiddaw Slate Series *must* be L. Llandeilo because Graptolites *do* occur throughout, or nearly so, I for one am inclined to demur. Could a L. Llandeilo *assemblage* of fossils be shown to prevail throughout the series, the case would be different. But it so happens that among the Trilobites there are several Tremadoc forms —see notes by Mr. Etheridge, F.R.S., at the end of the Survey Memoir—and with them a species of *Cybele* hitherto only represented by species not occurring below the Caradoc rocks. Certainly the scanty evidence to be derived from the group of Trilobites is conflicting, and besides Trilobites and Graptolites, we have but a few doubtful plant-remains, carapaces of Phyllopod crustacea, a *Lingula* (*brevis*), and doubtful *Discina*, and worm-tracks. Under these circumstances no wonder that the Graptolites are referred to as the most important. Hence we have the evidence of this group in favour of the L. Llandeilo age of the Skiddaw Slates, and the evidence of at least part of the Trilobite fauna in favour of the Tremadoc age of *portions* of the series. The question arises, are we justified in saying that such and such beds below a certain horizon cannot be of Tremadoc age because beds believed to be of that age in Wales do not contain Graptolites? A thin grit in Wales separates black slates above, containing Graptolites, from black slates below not containing them; the upper are called Arenig, the Lower Tremadoc: are we to assert from this that, such being the case in Wales, *so far as our experience goes*, no black slates, whatever their physical position, which *contain Graptolites*, can be of Tremadoc age? Surely not. In Cumbria we have a grit, similar to the Arenig grit of Wales, with black slates above containing Arenig Graptolites, but in this case the black slates below also contain them; therefore the palæontologist says these cannot be Tremadocs, and yet there may be but 50 feet or less of grit separating the two series. For my own part, while ready enough to accept the evidence of palæontology when it is presented in the form of life assemblages, I do decline to pin my faith as to the succession and equivalence of rock-groups to the evidence afforded by the finding of a few

Graptolites below a certain horizon, such an horizon not necessarily indicating any long break.

Among rocks in which there so frequently occur great thicknesses of wholly unfossiliferous beds, the mere absence of a particular fossil or group of fossils cannot go for much. Thus, over large tracts of the Lingula Flags in Wales, no Lingulas or other fossils occur, while in some spots they may be plentiful enough. Hence, although no *Lingula Davisii* has been found in the lower sandy series of Whiteside and Grasmoor, this cannot be used as evidence against the Lingula Flag age of these beds if that be supported on general physical grounds.

Summary of Evidence.—The Physical evidence inclines one to believe that the Skiddaw Slates include the Arenig Slates, the Arenig Grit, the Tremadoc Slates, and the Lingula Flags. The Palæontological evidence, based on no complete assemblage of life, and having no fossiliferous formations to which to refer above and below, suggests an Arenig age for the whole series on one score, and a possible Tremadoc age for portions of it upon another score. Hence, may we not conclude it to be at all events very possible that in Cumbria we have the equivalents of the Welsh rocks down to the Lingula Flags?

If we consider the Lingula Flags and Tremadoc Slates as Cambrian, all that portion of the small Sketch-map denoted by broken vertical lines will represent the Cambrian, and that above the Grit the Silurian.

Explanation of SKETCH-MAP, Plate II. (Geol. Mag. Feb. 1879, p. 49.)

Fig. 1. Diagrammatic Section, from N. to S., to show general structure of District.

Fig. 2. Diagram to show plateau of marine denudation, at the close of the Old Red period. The pattern used to denote the Upper Silurians is not meant to indicate that the strata are vertical, though they are generally highly inclined.

Sketch-map of the Geology of the Lake District. The lines along which the Horizontal Sections on p. 54 are drawn are indicated in the Sketch-map.

APPENDIX.

List of Papers, by the Author, on Lake District Geology, to be referred to in connexion with this Paper.

Notes on the Microscopic Structure of some Ancient and Modern Volcanic Rocks. Quart. Journ. Geol. Soc. vol. xxxi. p. 388.

On the Granitic, Granitoid, and associated Metamorphic Rocks of the Lake District. *Ibid.* vol. xxxi. p. 568, and vol. xxxii. p. 1.

Part I.—On the Liquid Cavities in the Quartz-bearing Rocks of the Lake District.

Part II.—On the Eskdale and Shap Granites, with their associated Metamorphic Rocks.

Part III.—On the Skiddaw Granite, and its associated Metamorphic Rocks.

Part IV.—On the Quartz-Felsite, Syenitic, and associated Metamorphic Rocks.

Part V.—General Summary.

The Geology of the Northern Part of the English Lake District. Memoirs of the Geological Survey. Longmans & Co., and E. Stanford.

Notes on the Occurrence of Chlorite among the Lower Silurian Volcanic Rocks of the Lake District. Mineralogical Mag. No. 4.

On the Lower Silurian Lavas of Eycott Hill, Cumberland. Monthly Microscop. Journ. 1877, p. 239.

Glaciation of the Northern Part of the English Lake District. Quart. Journ. Geol. Soc. vol. xxix. p. 422.
On the Origin of some of the Lake Basins of Cumberland. *Ibid.* vol. xxx. p. 96.
The Glaciation of the Southern Part of the Lake District, and the Glacial Origin of the Lakes of Cumberland and Westmoreland. Second Paper. *Ibid.* vol. xxxi. p. 152.
Notes on the Archæological Remains of the Lake District. Trans. of the Cumb. and West. Ant. and Arch. Soc. part ii. vol. iii. p. 241.

IV.—The Devonian Question.

By A. Champernowne, M.A., F.G.S.

In last month's Geological Magazine there is much (by three writers) that bears upon the Devonian Question, and I would now add a few words on the same subject, which is of the greatest interest to me.

In the first place, notwithstanding that two of the writers are my personal friends, I think that the united criticisms upon Prof. Hull's proposed classification exceed what the nature of the case calls for, as that scheme contains the most essential elements of truth. I have myself been in North Devon during the last autumn with Mr. Ussher, and we hope to give a further account of our work and the conclusions arrived at. My chief object in going there was to test certain opinions I had before expressed with great confidence (in these pages and elsewhere), and, as a result, I have proved to my satisfaction that those opinions were wrong.

Neither by fault, nor inverted junction along the line indicated by Jukes, is there any wholesale reduplication of the North Devon Series. The fault I had already taken to be disproved by Mr. Etheridge's paper (Q. J. G. S. 1867). In the last paragraph of Mr. Kinahan's paper he observes, that "Jukes' fault has not been disproved, and that the Irish geologists who have been in Devon believe in its existence." This, however, from Prof. Hull's classification, is evidently not his opinion, as he places the Ilfracombe and Morte slates beneath the Pickwell or (Upper) Old Red Sandstone, but he suggests an unconformity at the base of the latter, of which there is no evidence.

Regarding the Pickwell as what Mr. Kinahan aptly calls the Carboniferous Old Red, I will venture to say that in nine out of ten Western European areas a break[1] might be expected at a corresponding horizon, but the North Devon marine sequence is almost unique in its completeness. My former belief in an inverted passage assumed perfect conformity at that junction, and of this conformity there are indisputable proofs.

[1] Of all areas in which rocks belonging to the Siluro-Carboniferous interval are developed, that of the Welsh border counties, although geographically the nearest, is perhaps the least comparable of any to the North Devon area, and the greatest stumbling-block to a would-be "Devonian" disciple. In vain may be the search there for a break of any magnitude to be filled in from the latter area. Lacustrine conditions may have prevailed more or less, from the final retreat of the Ludlow types, until the waters of the Lower Limestone Shale united the "Welsh Lake" (see Prof. Geikie's Lectures on the Old Red Sandstone) with the ocean. In South Ireland and Devonshire, on the other hand, there are plain indications of an open sea to the South and East, extending into the Rhine country.

The absence of a "Middle Devonian" (with its peculiar forms of life) anywhere in the United Kingdom, save North and South Devon only, was enough to stagger one and shake one's faith in fossils; and no unconformity in the heart of the Old Red Sandstone districts appeared originally to me to be sufficiently significant to explain its absence. Nevertheless, the rock groups north of the Pickwell Series *are* unquestionably distinct from those south of it.

With regard to Mr. Hall's expostulation as to there being no fossiliferous "Upper Devonian" in Prof. Hull's scheme, that surely is a question of nomenclature, and, expressive as the local names 'Marwood' and 'Pilton,' 'Baggy,' 'Cucullæa zone,' certainly are, I think that the only philosophical classification ultimately attainable will be to drop the term "Upper Devonian" as applied to these beds altogether, or regard it simply as a synonym for Lower Carboniferous, in cases where that period is not represented by good Carboniferous Limestone. In this respect I still think Jukes was undoubtedly right. Therefore I would apply the term Devonian as high as Prof. Hull applies it, regarding the Pickwell as the conformable base of the Carboniferous. This will still leave us the great Ilfracombe-Morte Series as Devonian, and the Linton grey beds as a *lower* fossiliferous Devonian.

The presence of land-plants of Carboniferous genera in the Marwood beds would be in harmony with this view, and the great profusion of a *Productus* in the gritty beds of the Pilton Series at Croyde Bay, etc., would make it probable that they represent (in time) the lower parts of the Carboniferous Limestone.

There are not wanting signs that Prof. Hull's suggestion about the Silurian affinities of the Foreland Sandstones *is worth a great deal.* In the red and variegated beds of the Lincombe Hill, etc., exposed along the New Cut at Torquay, Mr. Lee and I found many portions of *Homalonotus armatus*, Burmeister. The genus *Homalonotus* being essentially Cambro-Silurian and Silurian, suggests at least that these beds, which contain also *Chonetes*, *Holopella* and a small *Myalina*, may have some Silurian affinities, and may be as low as the lowest North Devon beds. At the same time there are among them some grey red-speckled siliceous grits with superficial raddling, which resemble those of the Hangman Series, and as the South Devonian rocks are not nearly so complete as those of North Devon, it is quite possible either that the true Hangman Grits may be absent, or that beds belonging to the three lower groups of the North, Foreland, Linton, and Hangman, may be somewhat inseparable in the South; the Meadfoot grey and brownish grits and schistose beds might well represent the Linton. Great N.W. and S.E. faults, shifting an earlier set of fissures, cut out parts of the series in the Torquay Promontory.

As a matter of pure speculation, I see no reason why the Homalonotus red flagstones of the Eifel district should not prove to be a Silurian rock rising from below the Coblentzien (Lower Devonian) of Daun, Prüm, etc.

To resume then: I believe Sir Roderick Murchison[1] was right as

[1] Siluria, 4th edition, p. 282.

to the comparative structure of South Ireland and North Devon, and that the great unconformity shown in the centre of Mr. Kinahan's woodcut (Geol. Mag. 1879, February No. p. 68, Fig. 1), represents the missing Eifelian system; missing in South Ireland, not from denudation, but from having never been deposited in that region. The Glengariff and Dingle Grits would therefore have been upturned and denuded, and remained land or shoal water during the time that the Ilfracombe-Morte Series was accumulating in a steadily subsiding area, which is now North Devon and West Somerset.

I have crossed the mountainous country from Macroom to Killarney, which route affords grand sections of these massive grits, so that their characters are somewhat known to me, and I know them also on the Upper Lake of Killarney, and at the Gap of Dunloe.

Taking all into consideration, the conclusions of Prof. Hull appear to be in the main legitimate deductions from the facts, and not mere theory.

Dartington Hall, Totnes, Devon.

V.—The Devonian Question: Reply to Mr. Kinahan's Note.

By Professor E. Hull, M.A., F.R.S., etc., etc.

In the Geological Magazine for February will be found a "Note in Press," appended by Mr. Kinahan to his paper on the "Silurian Rocks of Ireland," read some time ago before the Royal Geological Society of Ireland, and which I had an opportunity of hearing and replying to. On that occasion I pointed out some of the numerous defects and erroneous views which this paper contains; and I could have wished that the matter had rested here, because I consider it highly unbecoming that the Director of the Survey should enter into a public controversy with one of his staff on points connected with the geological structure of the country which has been entrusted to him for elucidation. On the English and Scotch Surveys such conduct is happily unknown, and however the field surveyors may differ amongst themselves, and maintain their opinions in print, there has always existed a sufficient feeling of respect for the heads of the Survey, as well as a just consideration of the interest and credit of the Survey itself, to prevent open controversies with the heads of the Survey in the public prints. To this rule Mr. Kinahan presents the solitary exception. I cannot take blame to myself for having provoked the "Note in Press" to which I have referred, because there is nothing in my paper, published in the Geological Magazine, Decade II. Vol. V. 1878, p. 529, to call forth the statement on the part of Mr. Kinahan that I had made "various errors in reference to the Irish rocks."

If, then, I depart from the rule I have followed for several years in reference to Mr. Kinahan, of passing over his unseemly language in silence, it is with the understanding that this rule will be adhered to on all similar occasions, and that my silence in the future must not be construed into acquiescence, either in his statements of supposed facts, or his conclusions.

I shall now touch briefly upon his points *seriatim*, as stated in his "Note in Press" (p. 73), which seem to call for reply.

First.—Mr. Kinahan says: "If this be allowed" (*i.e.* the Silurian age of the Dingle and Glengarriff Grits in which "*all* Irish geologists who have studied them agree"), "we have a vast *continuous* series of rocks which represents ALL THE TIME intervening between the accumulation of the typical Silurian (beds) of Dingle and the typical Carboniferous (beds) of Cork."[1]

This is a remarkable statement in the face of the fact—that in the Dingle Promontory there exists between the "Upper Silurian" Dingle beds and the Old Red Sandstone (and consequently the overlying Carboniferous beds) an unconformity scarcely exceeded in amount by that between any two sets of rocks in the British Islands—by which the Old Red Sandstone rests on beds in some places 12,000 or 15,000 feet higher or lower than in others. If this is Mr. Kinahan's idea of a "continuous series" representing all the time between the Silurian and Carboniferous, his notions are special and peculiar. In my paper (GEOL. MAG. Nov. 1878) I suggested that this great gap in the Irish series is filled up by the Marine Devonian beds of Ilfracombe and Mortehoe—a suggestion which seems to bring the Irish beds into remarkable harmony with the Devonshire series.

Mr. Kinahan next attempts to commit me to the following absurdity. Because certain plant-remains (which I have seen) are stated on somewhat doubtful authority to have been found in the Glengarriff Grits south of Dingle Bay—and are also "said by Baily" to be found at Kiltorcan in the Upper Old Red Sandstone—therefore he supposes I have stated that the Glengarriff Grits are at one place Upper Silurian, and at another Old Red Sandstone!

This process of reasoning, besides being a little amusing, involves several postulates which I do not admit.

First, from the appearance of the plant-remains found in Kerry, I strongly suspect they have been got out of the Lower Carboniferous Slate and Coomhola Grit Series rather than out of the Glengarriff beds. If Mr. Kinahan had been a little more candid, he would have admitted that when we examined these plant-remains the other day in this Office, great doubts were expressed by others, as well as by myself, of their having been found in the Glengarriff Grit Series at all.

I also distinctly deny the supposed conformity *in the sense of continuity* of the Carboniferous and Upper Old Red to the Glengarriff Grit Series; and of this I hope to give sufficient proof in a paper now in the hands of the Secretary of the Geological Society of London, but not yet brought before the Society. On the contrary; the wide lapse of geological time represented by the great discordance in the beds north of Dingle Bay is represented also by at least as great a break in continuity south of Dingle Bay—where the Lower Carboniferous Slates and Grits come directly in contact with the Glengarriff Grit Series (as at Kenmare, Sneem, Glengarriff, etc.), without the intervention of the true Old Red Sandstone of Dingle,

[1] The italics are Mr. Kinahan's own.

Tralee, etc., a fact which Mr. Kinahan, with all his experience, has failed to discover for himself.

For my part, I cannot be guilty of the absurdity of supposing that beds separated by a gap (represented by 12,000 feet of strata) on one side of a small bay, that of Dingle, can be in a position of *continuous* sequence on the other side; yet this view appears to be held by Mr. Kinahan ("Geology of Ireland," p. 52, etc.).

As regards the beds of the Curlew Mountains, which are shown on the maps of the Geological Survey as Old Red Sandstone, Mr. Kinahan considers them to be "stratigraphically similar" to those of the Glengarriff Grit Series. This is a view peculiar to Mr. Kinahan himself, who can have but little personal knowledge of these beds, and different from that entertained by the officers of the Survey who surveyed the ground. Professor Jukes calls these beds "Old Red Sandstone" in his paper "On the Felstones of the Curlew Hills" (Journ. Geol. Soc. Ireland, vol. i.); they were so denominated by the late Mr. Foot, and by Mr. Cruise, who surveyed the ground; as also by Sir R. Griffith in his Geological Map of Ireland (1855), who places these beds (Fc) on quite a different geological horizon from the Dingle Beds and Glengarriff Grits (which are marked Ee). I am not surprised at this unanimity of opinion, in which I entirely concur, as the beds of the Curlew Hills, consisting of dark red and purple sandstones and conglomerates, bear little resemblance to the hard green grits and purple slates of the Glengarriff Series.

Mr. Kinahan proposes to abolish the Old Red Sandstone from the Geological Map of the South of Ireland—entirely ignoring the fossil evidence, which is of a very striking kind. There is, first, the presence of the fresh-water bivalve *Anodonta Jukesii*; then the remains of Old Red fishes, such as *Coccosteus, Pterichthys,* etc.; and plants like the noble *Adiantites* (*Palæopteris*) *Hibernicus,* not found in the overlying Carboniferous beds. Now, while these beds, lying at the top of the true Old Red of the South of Ireland, thus indicate freshwater conditions, those of the succeeding Carboniferous Slate show only marine conditions, as indicated by numerous species of Mollusca.

As Mr. Kinahan has done me the honour to point out my "errors" in reference to Irish rocks, he cannot, therefore, object to a similar piece of service on my part. I might enumerate many, but will content myself with two instances.

In his paper already referred to (Geol. Mag. Feb. p. 69) he says: "In the Ballycastle Coal-field, to the north-east of Antrim, Old Red Sandstone occurs interstratified in the Coal-bearing Calp." Now, "Calp" is the term used in Ireland to denote the middle earthy beds of the Carboniferous Limestone. Thus, while Mr. Kinahan would obliterate the Old Red Sandstone lying at the base of the Carboniferous beds, with its fresh-water shells, its peculiar fish, and remarkable flora, from the South of Ireland, he would introduce it amongst the Coal-bearing beds of county Antrim. This is, to say the least, a novel position for the Old Red Sandstone.

The beds referred to are red sandstones with a conglomerate base which occur in the lower portion of the Ballycastle Coal-field. Some years ago I pointed out, in a paper published in the Trans. Roy. Geol. Soc. Ireland, vol. ii. (1871), and therefore accessible to Mr. Kinahan, the analogy between the beds of the Ballycastle Coal-field and those of the Lower Coal-formation and underlying Calciferous Sandstone Series of Scotland—referring the beds to a similar geological horizon. On the publication of the paper, Professor Geikie expressed his concurrence in my views. According to Mr. Kinahan, however, we have an intercalation of Old Red and Carboniferous rocks, unknown elsewhere amongst British formations.

Mr. Kinahan seems to deny the existence of Permian beds near the City of Armagh,[1] as coloured and described in the Survey publications, and for the purpose of doing so, deliberately mis-states the position of the beds at this spot, notwithstanding clear and explicit descriptions given in at least two publications,[2] accompanied by sections, showing the position of the Permian beds with reference to the Carboniferous Limestone. These beds consist of sandstones, breccias, and conglomerates, resting on the marble beds of the Carboniferous Limestone, and after I had (in 1872) identified them as Permian beds, they were visited by Prof. Ramsay, who concurred in my view, recalling as they did to his mind the "brockram" of the Vale of the Eden. Mr. Kinahan, however, dissents from the views of Professor Ramsay and myself, which he is at perfect liberty to do; but in order to justify his dissent, makes a statement which is entirely erroneous, namely, that Mr. Egan, who surveyed the ground, has proved that the supposed Permian beds are "interstratified" with limestones with fish-remains;[3] and secondly, that the limestones of Armagh belong to the upper division of the Carboniferous Limestone Series. If this is so, then the maps of Sir R. Griffith and of the Geological Survey, which represent the beds near Armagh as Lower Limestone, are altogether wrong.

Mr. Kinahan has been commended for his disregard of "authority," and unquestionably independence of opinion is a high quality in a man, provided it be accompanied by candour in stating the case as against himself, and weighing the views of others. The instances I have given will suffice to enable the reader to form his own conclusions on this question.

I have now done with Mr. Kinahan's views; nor shall I again be tempted to notice them. Except for the discredit they are calculated to bring on that branch of the public service to which he belongs, they might well be passed over in silence. Perhaps, after all, even this apprehension is groundless.

Geological Survey Office, Dublin,
12th February, 1879.

[1] "Geology of Ireland," p. 133.

[2] Quart. Journ. Geol. Soc. Lond. vol. xxix. p. 402, and Explan. Memoir to Sheet 47, by F. W. Egan, p. 11 (1873).

[3] There is no reference given for this statement, and Mr. Egan, in a letter in my possession, says: "In reply to your letter of yesterday, I fail to see where I have proved that the red and other coloured sandstones (considered by you to be of Permian age at Armagh) are interstratified with limestones."

NOTICES OF MEMOIRS.

Notice of Prof. A. Heim's work on the Mechanism of the Formation of Mountains.[1] By Prof. E. Renevier.

THIS work is an important one, not only from its being a conscientious study of a very interesting Alpine region, but also from its containing the result of the author's systematic researches on the mode of formation of the Alps and of mountain chains in general.

Prof. Albert Heim, former pupil of the late Escher von der Linth, replaced the latter on his lamented decease in the Chair of Geology at the University of Zurich and at the Federal Polytechnic School. He has profited not only by all the experience of his master, but has had the use of all his manuscript and unpublished notes. Besides having often traversed the Glarus Alps with our regretted colleague, he has studied them more in detail for a number of years. In these explorations—as well as in his numerous travels across Europe, from Sicily in the south to Norway in the north—he has fixed his attention especially on the different alterations and dislocations of rocks, and on the physical causes to which they have been subject. This is also the dominant point of view in the work to which we have the pleasure to point, and it is this which the author has wished to signify by the phrase, "Mechanism of the Formation of Mountains." From the wide generalizations in which Prof. Heim's book is very rich, it commends itself not only to the notice of Swiss geologists, but also to those in other countries who are interested in the physical laws which govern our world.

The work consists of two 4to. volumes, accompanied with a magnificent atlas of 17 large folio plates, of which 14 are chromolithographs. The first two are geological maps, one on the scale of $\frac{1}{100000}$ of the mass of the Tœdi and its environs, the other on the scale of $\frac{1}{250000}$ representing the Glarus Alps and chain of the Grisons to the north-west of the Rhine. The plates following contain geological sections to true scale, without exaggeration of heights, also drawings and sketches, done with the hand of a master—exact execution being guaranteed, since they have been put on stone by the author himself.

Vol. i. 350 pages, contains the geology of the Tœdi mass, whilst the second, of 250 pages, is devoted to the discussion of general orographical principles applicable to all mountain regions. They are complementary of each other and form one inseparable whole.

The Tœdi-Windgælle group of mountains is at the eastern extremity of the Finsteraarhorn mass of crystalline rocks. The Reuss, Linth, and Hinder Rhine have their sources in this district. We find there rocks of very different age, protogine occurring at a short distance from Eocene beds.

The first volume is divided into five parts, of which the first is devoted to the description of the crystalline rocks which form the

[1] Mechanismus der Gebirgsbildung im Anschluss an die geologische Monographie der Tœdi-Windgællen-Gruppe. 2 vols. 4to. with Plates. (Bâle, 1878.)

central nucleus of the mass. The granite of Puntaiglas, the porphyry of the Windgælle, have a special interest. The various schists of the central mass are repeated in the transverse section making the anticlinal and synclinal folds. The central mass itself contains Verrucano and Carboniferous beds—part of the Verrucano being contemporaneous with the latter formation.

The second part treats of the beds which form almost a complete series from the Carboniferous to the Eocene. Fossils are in general scarce enough; they are sufficient, however, to prove the existence of the Liassic, Jurassic, and Cretaceous formations. The author notices among others *Ammonites raricostatus* found for the first time in the Central Alps.

But that which gives the principal interest to this region is the gigantic foldings of the crust, of an intensity and extent the like to which has not been observed elsewhere. The reversals are so considerable that they surpass in extent and interest even the very curious case of the Dent de Morcles, which I noticed on a former occasion.[1]

The third part of the volume is occupied by a description of these complicated foldings. One enormous fold, bent over towards the north, borders the northern margin of the central mass; by this reversal the Jurassic, Verrucano, Porphyry, and even the Gneiss, are piled up on the Nummulitic. In the direction of the Windgælle, to the lower Landalp, this fold breaks up into a large number of minor ones. At the southern border of the central mass, we find that the chain of the Piz Tumbif is formed by a fold which is again folded—a compound fold. The middle zone, consisting of calcareous sediments, which is elevated on the back of the crystalline mass, penetrates, in some places, into this, forming very much compressed synclinals. The Tœdi itself is an enormous block of Jurassic Limestone, which has been separated from the surrounding masses of similar nature by prodigious denudation. At the top of the Bifertenstock are seen the Nummulitic Limestones, at a height of 11,300 feet. Many of the most remarkable folds of this region had remained unknown hitherto.

The fourth part of vol. i. contains a description of the well-known double fold which passes by the name of the *Glarner Doppelfalte.* Escher von der Linth was the first to discover this feature, which reverses absolutely the position of the beds over an extent of 454 square miles. Several geologists maintained that a reversal of such an extent was impossible, inadmissible! Such an opinion had for its excuse an incomplete knowledge of the locality. The present work is the first which gives an account of the phenomena over the whole of the reversed area. The mechanical explanation which Escher had broached we find here confirmed and developed in all its details.

Apropos of this, already in the first volume are a number of general researches, among others, on the theory and formation of reversed folds. We also find there suggestions for a uniform mode of indicating the different parts of a fold, etc. Finally, the author

[1] Archives des Sciences physiques et naturelles, 1877, May number. [Geneva.]

shows that the Glarus double fold is the mechanical continuation of the central mass of the Finsteraarhorn—that the latter is also formed by lateral displacement—that these different mountains are of the same age, and must have been produced during the Miocene or Pliocene epoch.

The last part of the first volume treats of the form of the surface; and in different chapters are considered successively—glaciers, the effects of Quaternary glaciers in the district, avalanches, springs, and specially the relations of erosion to the present configuration of the surface. Denudation has destroyed absolutely the original shapes which would correspond to the internal structure of the mountains. The Alps in our day have no longer half their pristine mass, more than half has been removed by erosion. We recognize in the form of terraces, on the sides and floors of valleys, the remains of old beds up to a height of 6,500 feet above the level of the present bed. These terraces are entirely independent of the structure of the mountain, but they correspond with those of the confluents of the same river, and differ in the valleys formed by the different main rivers.

Professor Heim thinks that the necessary conclusion from these facts, is that the valleys of the Alps are due entirely to erosion. If fissures or synclinal lines have in the first place fixed the direction, this must have been far above the present peaks and actual crests and in rock which has long disappeared. Many of the large rivers existed before the mountains which now surround them. Erosion acts from the mouth of a valley upwards, the valleys eat more and more back into the hills, and are often intersected. In a special résumé the author enumerates the arguments with which he meets those geologists who assume that mountain-valleys are ruptures of the earth's crust.

In the second volume the first part is entitled "Mechanical distortion of rocks by the elevation of mountains." The phenomena of folding, rupture, cleavage, etc., are examined as to their physical relations. The outcome is, that distortion without fracture can be produced in rocks which had already acquired their present hardness. The new observations belonging to these phenomena are grouped under sixteen laws. The author developes the result of an examination by the microscope of rocks crushed by pressure—this can even produce chemical changes. The following chapter contains the physical explanation of these phenomena—it may be stated shortly thus: At a certain distance below the surface rocks are found under a pressure much greater than their power of resistance; this pressure spreads in all directions as in a liquid. Rocks are thus reduced to a latent plastic state. Directly that a new force like lateral pressure—such as causes the elevation of mountains—acts on the mass, a homogeneous change of form results. Neighbouring surface rocks are distorted in yielding. The thrusts which have acted during crumpling of the Alps are in accordance with theory and experience.

A second part of the volume is devoted to the central masses of the Alps. Some geologists imagine that these crystalline centres play the part of active eruptive rocks, and have elevated the Alps in thrusting off the sedimentary masses to the right and left. Messrs. Favre, Suess, etc., on the contrary, regard the central masses as formed within folds. Prof. Heim is of the same opinion; he shows that all the eruptive rocks of the Alps are much older than the elevation of the chain, which proves that they have merely played a passive part, like the sedimentary rocks themselves, during the elevation. Certain central masses, like that of the Simplon, form large and well-preserved anticlinals. All intermediate conditions are found between this regular form and the fan-structure, which is nothing but an excessive folding. There is no definite separation between the crystalline schists of the central mass and the sedimentary rocks associated with them in the interior of the mass. While the crystalline schists have ordinarily a high dip, we see them in some places but slightly inclined, and absolutely parallel to the limestones. The unconformities which exist between the two groups of rocks are often not original; they are produced neither by cooling effects nor by a former elevation, but simply by a difference of movement during the uplift of the Alps. According to Prof. Heim the clearest proof of the inactivity of the crystalline rocks is given by the repeated demonstration—amply detailed in the volume—that the central mass itself has undergone an enormous lateral compression, which by crumpling has reduced this zone of the crust to half its original width. The central masses are then zones of folding of the crust, of a "mechanical facies," only a little different from what is frequently seen in calcareous formations. The difference is perfectly explained by that of the weight which acted on one and the other group of rocks during the lateral displacement.

The last part of the work is headed "On the structure and formation of mountain chains." The author groups here the results of preceding researches. After an historical account of different views successively put forth on the elevation of mountains, Prof. Heim describes in a general manner different phenomena of dislocation in their interior. The lateral displacement, which he recognizes as sole cause of the formation of chains, can be measured on horizontal sections in stretching out the folded beds. A contraction only of $\frac{1}{100}$ of the earth's circumference would have sufficed to fold the crust in a way to form all the mountains found on the meridian crossing the Alps.

The remaining chapters contain researches on the distribution of lateral displacement on the surface of the globe, on the relation of different sorts of mountains between themselves and continents, as well as on the proximate causes of their formation. The author, in conclusion, attributes foldings of the crust to the diminution of the diameter of the globe, resulting from contraction by cooling of the internal mass. Prof. Heim estimates at 50,000 mètres the diminution of the earth's radius, and thinks that the result would be the same under either hypothesis of the fluidity or solidity of the internal nucleus.

The analysis above given of this important work is in large part due to the author himself, who has furnished the materials as far as the essential ideas of his book are concerned. The work is one which will certainly become classical.

LAUSANNE, 1878.

[Translated by E. B. T., from the "Archives des Sciences physiques et naturelles," 1878, November number.]

REVIEWS.

I.—A MONOGRAPH OF THE SILURIAN FOSSILS OF THE GIRVAN DISTRICT, IN AYRSHIRE, WITH SPECIAL REFERENCE TO THOSE CONTAINED IN THE "GRAY COLLECTION." By Professor H. ALLEYNE NICHOLSON, M.D., D.Sc., etc., and ROBERT ETHERIDGE, JUN., F.G.S., etc. Fasciculus I. RHIZOPODA, ACTINOZOA, TRILOBITA. 8vo. 135 pages and 9 plates. (Blackwood and Sons, Edinburgh and London, 1878.)

SOON after fossils were first collected and brought to notice in the district referred to, Sir Roderick Murchison devoted a large portion of a Memoir on the Silurian rocks of Scotland (in the Quart. Journ. Geol. Soc. London, vol. xvi. 1851) to the elucidation of the contorted and dislocated strata in which they had been discovered. He writes: "The most fossiliferous Silurian rocks yet discovered in Scotland lie directly to the East of Ailsa Crag, and to the north and south of the port of Girvan. . . . The rocks constituting the Silurian series of Ayrshire consist of (3) schists and limestones, (2) shelly greywackes, sandstone with conglomerates, and (1) limestone and schists," in ascending order. "These ridges are composed of strata which strike from W.S.W. to E.N.E., or parallel to the general direction of the Silurian rocks of the South of Scotland. The Girvan Water and the Stinchar flow in longitudinal depressions or fissures,[1] which are also coincident with the strike of the rocks" (pp. 141–3). Not only the recognition of the Girvan fossils (mostly collected in those days, we believe, by John Carrick Moore and Alexander M'Cullum) as Silurian, but the discovery that the old *Silures* had inhabited this part of Ayrshire, was a source of great gratification to Murchison; and he urged the further collection of the organic remains, and induced Mr. J. W. Salter to enumerate and describe those already in hand (*op. cit.* p. 170, etc.). Sedgwick and M'Coy also had already taken a similar interest in this Palæozoic locality, and had studied some of its fossils (Rep. Brit. Assoc. 1850, etc.).

With the progress of the Geological Survey the Silurians of Ayrshire became still better known (Explan. Sheets 7, 13, 14, and 15); and the importance of having their fossils definitely determined, and fully compared with those of Wales and elsewhere, was so strongly felt that a Government grant of £75 was obtained through the good offices of the Royal Society towards the work; and Robert

[1] The Geological Surveyors, however, did not find a general concordance of the lines of valleys with faults in this district, though the strike of the beds has certainly an influence on them. See "Explan. of Sheet 7, Mem. Geol. Surv. Scotland, 1869."

Gray, Esq., F.R.S.E., most liberally gave further means for the purpose. Mrs. Robert Gray's collection of the Girvan fossils is the most complete extant, and has been carefully studied. The authors, Mr. Lapworth, and the Geological Surveyors, have also had fossils collected for examination.

The first part of the proposed Monograph is handsomely produced, with good printing and paper, and with nine excellent plates, lithographed by C. Berjeau, F.L.S.

Among the *Protozoa* (and at page 10, among the *Rhizopoda*) are enumerated the obscure *Nidulites* and *Ischadites,* the better known *Saccammina* of H. B. Brady, and the less determinate *Girvanella* of N. and Eth. The remarks on the possible affinities of the first two are painstaking, and, though inconclusive, are useful in view of further inquiries. The Silurian age of *Saccammina,* a real Rhizopod, known also in both Carboniferous Limestone and recent seas, is very interesting; but not so wonderful as it would be did we not know of the persistency of low organic existences. Principal Dawson has enumerated several Silurian and pre-Silurian Rhizopods. The Rev. J. F. Blake has noted a Lower-Silurian *Dentalina*[1] at Aberystwyth; and the *Eozoön* is still unaccounted for by some mineralogists, and accepted by most Rhizopodists. The *Girvanella,* though obscure, has its analogues in Chalk flints, and in recent abyssal ooze.

The Corals, though numerous, are not well preserved. They have been very carefully and judiciously dealt with; and have yielded about 21 species in 15 genera. Those of the Craighead Limestone have Lower-Silurian characters; from the other localities they indicate Upper-Silurian age. *Chætetes* and *Fistulipora* are here included in the *Actinozoa* for convenience, though belonging possibly to the *Polyzoa.* In naming a new genus of Corals after Lindström, the authors should have written *Lindstrœmia,* instead of retaining the Swedish form of the diphthong. Though the German and some other printers abroad have not the necessary type, we have it, and should use it in Latinized words, such also as *Lindstrœmi* and *Kœnigi,* elsewhere in the Monograph.

Several of the Trilobites are described and figured in this Fasciculus. Great care has been taken both with descriptions and figures; also with synonyms, and the references to other writers and observers. This indeed holds good with the descriptions of the fossils throughout. We must remark that no reason is given why the Trilobites are retained among the "Entomostraca." Advanced Carcinology (as represented by Henry Woodward's "Catal. Brit. Crustacea," Brit. Mus. 1877) gives them a higher place, between the *Isopoda* and the *Amphipoda.*

A Bibliography of the Silurian Fossils of the Girvan District, from 1849 to 1878, occupies pages 1–6; and a list of definite localities of the fossils fills page 7. Everything promises well for future Fasciculi of this Monograph, so well begun; its good appearance and trustworthy contents are the praiseworthy results of careful printers

[1] Geol. Mag. Dec. II. Vol. III. p. 134.

and lithographers, of enthusiastic and experienced authors, working for love alone, and of liberal promoters. We sincerely trust that generous support will be given to this publication, so useful to geological science. T. R. J.

II.—The History of Coal. By the Rev. Thomas Wiltshire, M.A., F.G.S., etc. 8vo. 36 pages. (Spon, London and New York.)

GIVEN as an Introductory Lecture to the Evening Classes at King's College Winter Session of 1878, this concise, and yet elaborate history of the use of coal is remarkably well adapted to supply much-required information on a subject interesting to the thinking public. It will also excite a wholesome desire to learn all that can be learned about the nature, origin, and economic application of the valuable varieties of fossil fuel.

After two or three pages on the geological relations of coal to our own and other countries, also some remarks on the probable ignorance of the use of coal in pre-historic times, and on the general use of charcoal in early historic times, Mr. Wiltshire refers to the early mention of fossil fuel in Liguria and Elis, the former district still supplying lignite at Cadibona. The terms *anthraces, bitumen, Thracius lapis, obsidianus lapis, ampelites,* and *gagates,* as applied to lignite, mineral pitch, jet, and coal by ancient authors, and the supposed benefits derived from the various uses of these substances in early times, are learnedly discussed.

The more definite use of coal as fuel by the Romans in Britain, and possibly by the earlier inhabitants, is well worked out at p. 14, etc. At page 19 we enter on a later period, when, about A.D. 850, the monasteries appear to have recognized the value of coal (unless, indeed, *charcoal* is the substance referred to in their documents). In deeds and charters of A.D. 1190, however, the digging of coal is definitely referred to in the North of England and soon after in Scotland. The Newcastle Coal-field soon sent its minerals by sea along the south coast, and "sea-coal" became a household word in London, little as its use was approved of in town and country by old-fashioned people, and by those who for various reasons preferred wood fires and open hearths. The old colliery laws, often hard and arbitrary, the gradual introduction of sea-coal in London houses, in spite of prejudice and Royal decrees, and the gradual growth of the word "coal" from its olden forms, are fully treated. The introduction of steam pumping engines, and the invention of safety-lamps, to facilitate the working of mines, and then the increased demand for coal in the manufactures, arts, locomotion, and domestic use, brought about the changes which have so greatly influenced affairs among all classes and conditions of modern life.

The Appendices, including a Map, illustrate the relative supply of coal obtained from different countries; and especially the increasing quantity taken year by year from the British Coal-fields. Nearly 135 million tons of coal are raised every year in the United Kingdom and Ireland. In 1877 more than eight million and a half tons of coal came into the London District alone, sufficient to make a wall, thirty feet high and thirty feet wide, reaching from London to Brighton. The coal removed from our mines since the year 1800 would form a mass nearly a cubic mile in dimensions.

This enormous and increasing consumption of coal must have its limit before long. Were the rate to continue as now, and could coal be got from 4000 feet depth, we might look forward to England having 1000 years before her with coal at hand. Bnt the lavish use of this fossil fuel increases every year; and if the digging be practically limited to 3000 feet (as is most feasible), our combustible treasure can last for only 300 years! T. R. J.

III.—Journal of the Royal Microscopical Society, containing its Transactions and Proceedings, with other Microscopical and Biological Information. Edited by Frank Crisp, LL.B., F.L.S., etc. Vol. II. No. 1, February, 1879. 8vo. (London: Williams & Norgate.)

NEW life has been infused into this Journal through the energy and ability of its present Editor, Mr. Frank Crisp, who seems determined to make it a thoroughly useful and successful scientific periodical. The part just issued has a far richer complement of varied biological information relating to histology, than the former ones, inasmuch as notices of foreign discoveries are especially cared for; there is a full catalogue of books and journals, and of their contained memoirs, treating of microscopical research. The Transactions of the Society furnish eight illustrated memoirs to this Journal; and of the notes and memoranda there are fifty and more. There is little that bears on Geology in this February Number, except a notice of Prof. Verrill's discovery of *Cliona sulphurea* freely penetrating some marble blocks wrecked off Long Island in 1871.

T. R. J.

REPORTS AND PROCEEDINGS.

Geological Society of London.—I.—January 22, 1879.—Henry Clifton Sorby, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "On Community of Structure in Rocks of Dissimilar Origin." By Frank Rutley, Esq., F.G.S.

After alluding to the community in mineral constitution of certain rocks to which different names have been applied, and indicating the advisability of retaining some old terms in a provisional sense, questions relating to the causes of the angular and rounded characters of certain rock-constituents were discussed. The author then described some of the more common structural peculiarities met with in rocks of various origin, especial attention being directed to those in which micro-crystalline, crypto-crystalline, or micro-felsitic conditions have been either normally developed or superinduced; while other rocks were described in which corresponding structure, sometimes coupled with a similar mineral constitution, may be met with. Difficulties attending the determination of the origin of some clastic rocks were also pointed out, and the value of certain structural characters in their diagnosis were mentioned. Assumptions as to the origin of some fragmentary rocks were shown to be undemonstrable in certain cases, although such assumptions often carried much probability with them. The resemblances presented by devitrified rhyolitic rocks, felstones, and felspathic grits were dwelt upon at some length. The paper included a short structural classification of the constituents of rocks.

2. "Distribution of the Serpentine and associated Rocks, with their Metallic Ores, in Newfoundland." By Alexander Murray, Esq., C.M.G., F.G.S.

The author stated that no extensive display of serpentine is known in the Laurentian series in Newfoundland; nor is the existence of crystalline limestone of that age, with which serpentine is often associated, as yet well established. The Intermediate or Huronian system is singularly barren in lime, magnesian minerals, and mica; lime occurring almost exclusively as intersecting calcareous veins. Over all the known area of the system no masses of serpentine have been observed, and only one instance of the presence of a serpentinous mineral, which occurs in an intrusive mass intersecting the Intermediate system, and disturbing the outcrop of the sandstones of the Primordial Silurian (Lingula Flags) at a place called "The Broad" of Tickel Harbour, Trinity Bay, where some steatite with some seams of asbestos were seen near the contact. Wherever a typical fossiliferous horizon could be established, the stratigraphical position of the fossils placed those of the Lévis age, or older, below the serpentines; while in all cases, where the types were of Hudson-River or newer date, they as invariably succeeded unconformably above. Instances of this unconformable relation were mentioned in which the upper formation was as late as the Devonian age. The stratigraphical and palæontological break between the Lévis and Trenton groups is here filled up by a metamorphic mass which, in part at least, may possibly represent the horizon of the Chazy group; and the great intrusive masses have been connected with, or the cause of, the metamorphic phenomena displayed.

II.—February 5, 1879.—The President announced the receipt of a legacy of £1000, bequeathed to the Society by the late Sydney Ellis, Esq., of The Park, Nottingham.

The following communications were read:—

1. "On the Occurrence of Pebbles with Upper-Ludlow Fossils in the Lower Carboniferous Conglomerates of North Wales." By Aubrey Strahan, Esq., M.A., F.G.S., and Alfred O. Walker, Esq., F.L.S.

The authors described the mode of occurrence near Abergele of certain Lower Carboniferous conglomerates, best exposed in Ffernant Dingle, and especially of one containing numerous red and green sandstone pebbles, which inclose fossils of Upper-Ludlow forms, and lying above the so-called "Bastard Limestone." From the arrangement of the beds the authors believe that they may have been deposited against a bank or sloping surface of Wenlock shale; and they state that the great majority of the pebbles in the conglomerate are quite unlike any rock known in the district, but closely resemble the Upper-Ludlow beds of Kendal and Central Wales. The authors discuss the origin of the pebbles, and suggest "the probable extension of the Ludlow beds under Lancashire as the most likely source from which they can have been derived."

2. "On a New Group of Pre-Cambrian Rocks (the Arvonian) in Pembrokeshire." By Henry Hicks, M.D., F.G.S. With an Appendix on their Microscopic Structure by T. Davies, Esq., F.G.S.

In some new areas of Pre-Cambrian rocks discovered by the author last summer in Pembrokeshire, some rocks of a character hitherto unrecognized in this country were made out. As they were found to hold there, and subsequently also in other areas, a very definite stratigraphical position, with a vertical thickness of several thousand feet, they have been separated by the author from the other Pre-Cambrian groups under the distinctive name of Arvonian. They were also found to occupy an intermediate position between the Dimetian and Pebidian formations, and at all points, so far as could be made out, appeared to be separated from each of those formations by stratigraphical breaks. The new areas where they are chiefly exposed are situated some few miles to the north of Haverfordwest, where they form ridges running in a direction from N.E. to S.W. They occupy an average width of about a mile, attain at some points to a height of nearly 600 feet, and together have a length of over nine miles. The rocks are flanked by Pebidian and Cambrian beds along their N.W. borders, and on the S.E. Silurian rocks have been brought against them by faults. In general appearance, as well as in their more minute lithological characters, they are easily distinguished from any of the rocks hitherto described by the author as characteristic of the Dimetian and Pebidian groups in Pembrokeshire. They are, however, so closely allied to some of the true "hälleflinta" rocks of Sweden, that it seems to the author and Mr. Davies that this is the name that should be applied to them in a petrological sense. In external aspect and in their splintery fracture they resemble a hornstone. Under the microscope they are seen to consist mainly of a crypto-crystalline ground-mass, which, when examined with a high objective, is resolved into grains of quartz, with an interstitial ingredient having but little action on polarized light, but which presumably is felsite. There are also numerous nests and fissure-like groups of quartz-grains disseminated throughout, and sometimes angular fragments, distinct in size and shape, are enclosed. These nests and fissure-like groupings are frequently encircled also with bands of fibrous, chalcedony, the structure of which is well exhibited with polarized light, and a rude parallelism, suggestive either of an incipient foliation or of stratification, is thereby given to the rock. The author and Mr. Davies believe the origin of the rock to have been a sedimentary one.

3. "On the Pre-Cambrian (Dimetian, Arvonian, and Pebidian) Rocks of Caernarvonshire and Anglesey." By Henry Hicks, M.D.,

F.G.S. With an Appendix on their Microscopic Structure by the Rev. Prof. T. G. Bonney, M.A., F.R.S., F.G.S.

In this paper the author gave the results of some further researches made in Caernarvonshire and Anglesey since his previous communication to the Society on Dec. 5, 1877. A brief statement of some of the results was read at the last meeting of the British Association in Dublin; but much additional evidence was now brought forward, besides many important facts obtained since by microscopical examination of the rocks. Concerning the areas described in his former paper much additional information was given, and the boundary in one case greatly extended. This new area lies to the west of Moel Tryfaen, and includes now, in addition to the central or quartz-felsite ridge, the whole of the rocks marked in the Survey maps as altered Cambrian, extending as far west as Glynllifen. Many of the large masses in south-west Caernarvonshire and the Llyn promontory, hitherto supposed to be intrusive rocks of Silurian or Post-Silurian age, were discovered, during these researches, to be of Pre-Cambrian age, and conclusive evidence obtained that the so-called altered Cambrian rocks there, and in Anglesey, were also of that age. In these various areas the three Pre-Cambrian formations found in Pembrokeshire were recognized by having similar lithological characters, and in holding almost identical stratigraphical positions in their relations to one another. *Dimetian* rocks were recognized at Twt Hill, Rhos Hirwani, near Ffestiniog, and in the so-called granitic ridge in Anglesey. *Arvonian* rocks between Caernarvon and Menai Bridge, in the Eifl Range, Nevin Mountain, and near Ty Croes, in Anglesey, etc., etc. *Pebidian* rocks to the east of Glynllifen, Bangor, at the lower part of the Lynn promontory, and in many places in Anglesey. Some notes on the section near Ty Croes by Prof. Bonney accompanied the paper, in addition to an appendix by him on the microscopic examination of rock-specimens from each of the areas examined.

4. "On the Quartz-felsite and Associated Rocks at the Base of the Cambrian Series in North-western Caernarvonshire." By the Rev. Prof. T. G. Bonney, M.A., F.R.S., F.G.S.

The great masses of quartz-felsite (or quartz-porphyry) which occur in the vicinity of Bangor, Caernarvon, and Llyn Padarn, are coloured in the Survey map as intrusive, and in the memoir regarded as most probably the result of an extreme metamorphosis of the lower beds of the Cambrian series.

The author showed that these quartz-felsites exhibited, in places, all the characteristics of true igneous rocks—flow-structure, fissile structure, and the more ordinary structure of rhyolitic rocks; that they were, in one place, at least, associated with masses of agglomerate, and in another parted by a band of comparatively unaltered slate. He also showed that in several places there succeeded a grit formed of fragments of it, that larger fragments of perfectly characteristic structure, associated with others of a more slaggy and scoriaceous type, occurred repeatedly in the overlying beds up to the base of the Cambrian, described by Prof. Hughes and Dr. Hicks, the felsite pebbles in which come from the same source. Lastly, he showed that the signs of the metamorphism and apparent "melting down" asserted to be visible on the sides of Llyn Padarn, proved, on microscopic examination, to be mainly superficial. Hence, he maintained that these rocks were rhyolitic lava-flows of Pre-Cambrian age.

5. "On the Metamorphic Series between Twt Hill, Caernarvon, and Port Dinorwic." By the Rev. Prof. T. G. Bonney, M.A., F.R.S., F.G.S., and F. T. S. Houghton, Esq., B.A.

In the Geological Survey Map this district is coloured as "intrusive felsite," together with those spoken of in the last paper. It was asserted to be probably metamorphic rock by Prof. Hughes and Dr. Hicks in a communication made to the Society last year, and the first author confirmed that view by microscopic examination of a specimen collected by them. The authors had during the past autumn more minutely examined the district, and found:—(1) that the general character of the series was that of a metamorphic one; (2) that the rocks of granitoid aspect were associated with well-marked beds of conglomerate; (3) that this series extended up to a little beyond Port Dinorwic, where the quartz-felsite set in. The paper described the microscopic structure of some of the rocks, and the authors expressed the opinion that the more granitoid specimens were probably the results of alterations of felspathic grits.

CORRESPONDENCE.

THE TRIPARTITE DIVISION OF THE SILURIAN AND CAMBRIAN FORMATIONS.[1]

Sir,—Will you allow a still small voice from the frontiers of *Siluria* to say a word on Mr. Lapworth's proposal to call the rocks of the Second Fauna *Ordovician?* The lines have fallen to me in the pleasant places of South Shropshire, amidst the monuments of Murchison's genius. But Murchison is gone, the surveyors are gone (it is to be hoped they will come back again), and I am left almost alone to represent Caer Caradoc and Wenlock Edge. By the names of Murchison and Sedgwick (now, perhaps, in still happier hunting-grounds, recounting their old exploits, and wondering at their ancient squabbles), I implore the rival schools to accept the olive-branch! He who holds it is worthy to propose the compromise. Moffat and Girvan have witnessed his renown. Scores of faults and flexures testify to his skill. He has won an *Ordovicia* in the Scottish Uplands. Let true scientific frontiers be established! Let Barrande and Hughes meet together; let Cambria and Siluria recede from each other!

I am bound to record my humble protest against the present imbroglio. The want of a proper name for the rocks of the second fauna is most embarrassing. I have used "Lower Silurian" under protest, and "Cambro-Silurian" with dissatisfaction. Working some time ago amongst the Upper Cambrians of Salop, and being anxious

[1] This and the two following letters have been unintentionally delayed in publication.—Edit. Geol. Mag.

for all information on the subject, I eagerly waited for a paper announced for the Geological Society on a new "Cambrian" find in North Wales. The paper appeared, and the "Cambrian" turned out to be *Arenig*. The author, of course, was a student of the Cambridge School. Those of us who are simply workers, and not sectarians, should not have our tools broken by the worshippers of great names. CHARLES CALLAWAY.

WELLINGTON, SALOP, *January 6th*, 1878.

CHLORITIC MARL AND UPPER GREENSAND.

SIR,—I beg the favour of space for a brief reply to Mr. A. J. Jukes-Browne's questions which appeared in the GEOLOGICAL MAGAZINE for January, 1879. Mr. Jukes-Browne asks:

(1). "Why has he (Meÿer) changed his mind regarding bed 13 (of the Beer Head Sections), and why does he not identify it with the zone of *Belemnites plenus?*"

(2). "What does he mean in saying that he was therefore wrong in giving *Holaster subglobosus* so wide a range in his tables of fossils? Is it not found in the beds where he marks it as occurring?"

In reply to question (1): It would be hardly correct to say that I have changed my mind regarding bed 13. In 1874 I described it as representing Chalk Marl. More recent examination has convinced me that I am right in placing it *above* the Chloritic Marl, and I now identify it with the zone of *Belemnites plenus.*

To question (2) I can but repeat my acknowledgment (in GEOL. MAG. for Dec. 1878) of error in my tables of fossils of the Beer Head Sections.

For the rest I shall be happy to continue this discussion so soon as Mr. Jukes-Browne may have found "an opportunity of refreshing his recollection of the Isle of Wight sections," by reference to the disputed rocks and fossils *in situ.* By such time perhaps some acceptable term may have suggested itself which may replace that of *Chloritic Marl.* C. J. A. MEŸER.

January 6th, 1879.

SIR,—Having informed Mr. Meÿer of the typographical error which occurred in my last letter,[1] he has been good enough to send me fuller particulars, in answer to my questions, than are contained in his reply sent to you for insertion in the GEOLOGICAL MAGAZINE. I gladly avail myself of his permission to transmit them to you for publication, as they contain fresh evidence regarding the zones in the Devon cliffs. Mr. Meÿer writes to me as follows:—

"You may remember that in my description of bed 13 in 1874, I referred it to the base-bed of the Chalk Marl. That is to say, I considered it then as the lowest representative of the Chalk Marl of that particular district. I described it as distinct from the Chloritic Marl, because it even then appeared to me to represent Chalk Marl as to its matrix and older beds

[1] At p. 48, line 9 from foot of page, *for* "not" *read* "now."

only as to its remanié fossils. I had at the time no clear evidence of the horizon of the bed next above, not having then elsewhere sufficiently studied the fauna of the passage-beds from Chalk Marl to Chalk. In 1876, Barrois, as you know, referred bed 13 to Chloritic Marl. In 1877, and again in 1878, I re-examined the Devon cliffs, obtained much additional information, and satisfied myself that bed 13 belonged to a higher horizon than I had at first supposed. I found that bed 13 itself contained *Belemnites plenus*. That the bed next above it (bed 14) contained *Inoceramus labiatus*. That *Holaster subglobosus*, in some sections wholly absent, abounded here and there only in the top of bed 12, was to be found very rarely *in* the lower part of bed 13, but was not present in any of the other beds. In my tables of fossils of 1874 I had most unluckily included amongst supposed specimens of *Holaster subglobosus* the *Holaster nodulosus* of Hebert and *H. carinatus*, Ag., which are present in beds 11, 12, and probably also flattened specimens (seen only *in situ*) of *Echinoconus*, which occur rarely in beds 14 to 17. The result of my researches since 1874 in these particular sections amounts broadly to this—that I find reason for placing beds 13, 14, respectively a stage higher in the Cretaceous series than I had at first supposed."

I hope Mr. Meÿer will soon be able to publish the results of his recent researches in greater detail, as the zone of *Bel. plenus* appears likely to become an important divisional line in the Cretaceous series.

Jan. 8, 1879. A. J. Jukes-Browne.

SIR R. GRIFFITH AND THE OLD RED SANDSTONE.

Sir,—I find I have misrepresented Sir R. Griffith; from my conversation with him I imagined his statements in reference to the Fintona, Curlew Mountain and Croagh Moyle rocks had not been published; while now I learn they had been published in 1843, during the meeting of the British Association at Cork. For this correction I am indebted to the Rev. M. H. Close, President of the Royal Geological Society of Ireland. As that gentleman has in preparation a history of Griffith's Map, it is unnecessary to say more on the subject at present. G. Henry Kinahan.

Ovoca, *February 7th*, 1879.

ON THE FORMER CLIMATE IN THE POLAR REGIONS.

Sir,—Dr. Haughton's letter makes it look as if I had committed an anachronism in saying that Dr. J. Evans had, in his opening Presidential Address, defended his theory about changes of latitude against arguments subsequently brought forward in the Section by the Professor. It was, however, to a paper read by Dr. Haughton, in April, 1878, at the Royal Society, to which I referred.

O. Fisher.

Errata and Omissions.—In Mr. Lapworth's paper on the Tripartite Classification of the Lower Palæozoic Rocks, Geol. Mag., January, 1879.

After title insert—(Read before Edinburgh Geological Society, Dec. 19, 1878.)
p. 3, line 1, for *light* read *right*.
p. 3, line 40, for *division* read *divisions*.
p. 12, line 20, for *it* read *them*.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. VI.

No. IV.—APRIL, 1879.

ORIGINAL ARTICLES.

I.—On some Fish Exuviæ from the Chalk, generally referred to *Dercetis elongatus*, Ag.; and on a New Species of Fossil Annelide, *Terebella Lewesiensis*.

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

A NOT uncommon fossil of the Chalk, in both the upper and lower divisions, is an elongated, and more or less undulating body, composed of the scales and bones of fishes confusedly mingled one with another, and known to the quarrymen as "Petrified Eels." Dr. Mantell was the first to discover and describe these singular objects; he says, "A long cylindrical fish, of which neither the fins nor the extremities have been discovered, is one of the most frequent, but most imperfect of the Sussex ichthyolites. The specimens are of a subcylindrical form, rather flattened by compression, from six inches to two feet in length, and about one inch wide. They occur abundantly in the Upper Chalk, and occasionally in the siliceous nodules. They are, for the most part, perfectly straight; but some specimens are undulated, as if the fish had been suddenly enveloped in the Chalk while in a state of motion. The surface is covered with small delicate smooth scales, confusedly mixed together; not one instance having been noticed in which they are disposed with any degree of regularity."

"Until more illustrative specimens shall be discovered, our conjectures concerning the recent animal must be vague and unsatisfactory. That the remains in question are referable to a fish of the Order *Apodes* cannot, however, be questioned, and they certainly appear to be more intimately related to the genus *Murœna*, than to any other with which we are acquainted."[1] And he accordingly names them *Murœna? Lewesiensis*. In subsequent works[2] he refers them to *Dercetis elongatus*, Agassiz; probably from two small fragments in his collection, and figured in the work above quoted (tab. 34, figs. 10 and 11), regarding which specimens he says fig. 11 "is the only example" of *Murœna Lewesiensis* "that retains the slightest indication of a fin," whilst that of fig. 10 "shows vestiges of the tail, and of one fin, but no conjecture can be formed of the genus of the

[1] Fossils of the South Downs, 1822, p. 232, tab. 34, fig. 10, tab. 40, fig. 2.

[2] Medals of Creation, 1844, vol. ii. p. 658; Petrifactions and their Teachings, 1851, p. 438.

original" (p. 133). Yet these same fragments were subsequently figured by Agassiz, who, without hesitation, refers them to his *Dercetis elongatus,* as respectively anterior and posterior portions of the body;[1] an inexplicable allocation by either author; seeing that the specimens are each too obscure and fragmentary for certain identification, being mainly composed of rounded scales "confusedly mixed" with bones and fin-rays, and do not contain a fragment of a *Dercetis* scute. Whereas the species was actually founded upon two other specimens in good preservation in Dr. Mantell's possession; one containing the head and a large portion of the body with the characteristic dermal scutes *in situ,* and the other consisting of a portion of the vertebral column of a larger individual, also accompanied with the dermal plates, but in neither specimen are there any indications of scales.[2]

Moreover, by the aid of these two specimens Dr. Mantell designed and published a restoration in outline of this extinct fish,[3] in which no scales are represented. Nor does Prof. Agassiz in his diagnosis of either the genus or species mention other scales besides the scutes; and I may also add that I have examined many well-preserved specimens of *Dercetis,* and have not met with any trace of such a dermal covering. However, Dr. Mantell's determination has been generally adopted for these remains, though some collectors refer them to coprolites, and others to intestines of fishes. To the acceptance of either of the above views of their origin I have long been convinced that there are grave objections, founded upon an examination of numerous examples. That they are not the bodies of a species of fish, as confidently asserted by Dr. Mantell, is evident by the fact that they are collectively composed of debris of several species, and also, that scales of more than one species may frequently be detected upon the same specimen, the scutes of *Dercetis* being rare: neither are they coprolites, else they would occur in compact and less lengthened masses; and much less, from physiological reasons, can they be considered as intestinal. But the form and structure is highly suggestive of their being the remains of membranous tubes of large soft-bodied Annelides, of solitary habits, that collected and agglutinated, either for protection or disguise, the scales and bones of fishes to the exterior surface of their tubes; as some recent Annelides collect and attach by agglutination fragments of shells, grains of sand, and other substances to their dwellings. That they were tubular is shown by transverse sections of specimens which have been filled with chalk, and sometimes with flint, having the thin walls of the tube preserved entire; but this is of rare occurrence, owing to the extreme thinness of the membranous substance of which it was composed. And that they were

[1] Poiss. Foss. tom. ii. pt. ii. p. 259, tab. 66a, figs. 3, 4. Figure 3 is drawn as having a series of seven consecutive vertebræ; these had no existence save in the imagination of the artist, none being present upon the specimen; this and the other type-specimens of *Dercetis* figured by Agassiz are preserved in the National Collection, and each are as intact as when drawn for his work.

[2] *Op. cit.* tab. 66a, figs. 1, 2, and 5.

[3] Wonders of Geology, 1838, p. 309, fig. 39, and subsequent editions.

not burrowers, but lived and extended their dwellings upon the ooze of the sea-bottom, may be assumed from the covering of extraneous matter, their comparative straightness, position in the Chalk, and the great length they attained—Dr. Mantell says "from six inches to two feet," but this can only apply to lengths that have been extracted from the quarry, and which were originally longer, as no specimen with the extremities entire has yet been discovered. This prone habit is further confirmed by the fact that only in a few instances have I been able to trace the agglutinated debris completely surrounding the tube, as if, after the animal's death, it had been removed by the action of the waves from as much of the surface as was above the ocean-floor; or it might be that the animal did not in all cases agglutinate debris to the whole or to the inferior surface of its structure, for two casts from a quarry near Guildford, which admirably show by impression the membranous or horny structure of the tube, bear no indication of the attachment of any foreign substance, but, nevertheless, may be referred to the same species upon the evidence of a third fragment from the same quarry, which has precisely the same surface structure, but has also some scales attached and faint impressions of others. That the affixed debris left permanent impressions upon the substance of the tube is well displayed upon another cast which has been completely denuded of its covering, but retains deep imprints of the lost scales and bones. The above-mentioned specimens, and other interesting examples of this fossil, form part of the collection of J. R. Capron, Esq., of Guildford, which has recently been acquired for the British Museum.

Besides their irregular disposition, there are diverse individual variations in regard to the affixed substances: whilst some specimens are constructed of small and delicate scales intermixed with few or no bones, others are formed either of large or small scales associated with numerous small bones pointing in every direction along the membranous surface of the tube, but not extending beyond it, vertebræ being comparatively rare and of small size; long fin-rays, ranging from one inch to two and a half inches in length, enter largely into the composition of others, and are arranged fairly in the direction of the long axis of the specimen. An example of this variety is represented in Dixon's Fossils of Sussex, pl. 34, fig. 5; and there is a specimen in the British Museum, fourteen inches long, on which the appropriated rays exceed two inches in length.

I have detected scales of small specimens of *Beryx ornatus*, *Berycopsis*, and *Osmeroides Lewesiensis*; but most of the scales are too imperfect for identification.

That the animals that formed these dwellings (the only evidence known to us of their past existence) were solitary in their habits, is inferred from the circumstance that in no instance have two specimens been found in juxtaposition. And, imperfect as is the evidence respecting their natural position, I think we may, nevertheless, assume that they were branchiferous *Annelides* of the Order Tubicola; with affinities to one or other of the genera which construct their dwellings of sand or small stones, rather than to *Serpula*, or other recorded fossil genera that form calcareous tubes, and are, also, more or less gregarious. The recent genus *Sabella*, which belongs to the former division, contains species which construct calcareous dwellings; and Prof. M'Coy has described a species of this group (*S. antiqua*) [1] as occurring in the Carboniferous rocks of Ireland. But generic identifications founded upon such remains are necessarily conjectural and doubtful, as they yield no information regarding the anatomical structure of their former inhabitants; yet are nevertheless useful, in default of more precise knowledge, as aids to classification. With this view, and having regard also to the membranous tube, solitary life and habit of collecting organic debris for affixing to their domiciles, I am disposed to refer the makers of these dwellings to the genus *Terebella*, which includes one species, having analogous habits, the well-known shell-collecting *Terebella conchilega*.

Though Dr. Mantell failed in his interpretation of the natural position, and abandoned the name he first gave to these remains; yet his description of them is so clear and concise that the specific name he originally proposed must be retained, although objectionable as regards objects so generally distributed in the Chalk. I therefore propose that they be designated *Terebella Lewesiensis*, Mant. sp., until more authentic information regarding their origin is obtained.

II.—On the Correlation of the *Bournemouth Marine Series* with the Bracklesham Beds, the Upper and Middle Bagshot Beds of the London Basin, and the Bovey Tracey Beds.

By John Starkie Gardner, F.G.S., M.G.S. of France, etc.

In the spring of the year 1878 I brought under the notice of the Geological Society a paper describing for the first time as *Marine*, the Upper Series of the Bournemouth strata, present in thickness to the east of Bournemouth Pier. The publication has been delayed, but the present sketch will only to a very slight extent forestall it, and is written simply with a view to make clear the synchrony of the Bournemouth Marine Beds with the lower part of the *Bracklesham Beds* of the Hampshire Basin, the *Middle* and so-called *Upper Bagshot Beds* of the London Basin, and the *Bovey Tracey Beds*, the true position of the latter, especially, being more clear at the present moment than it was a few months ago. I propose first to describe briefly the Bournemouth Marine Strata, and then the other formations with which I have correlated them, in the order in which they are mentioned above.

The Marine Bournemouth Beds.—I have in the paper read before the Geological Society, pointed out the exact equivalents of each of the beds composing the series in the Alum Bay section. The marine or rather brackish-water beds first appear in a landslip almost under the Meyrick Road, a point some half mile east of Bournemouth Pier. From this point to Hordwell Cliff none of the

[1] Carb. Foss. of Ireland, p. 171, pl. 4, fig. 11.

strata appear due to purely freshwater action. Before I proceed further, I may as well at once meet an objection that may be urged against the purely freshwater origin of the Lower Bournemouth Series, that is, the occasional presence of Teredo-bored wood in it. This isolated fact for some time presented a grave difficulty, but in addition to the evidence recapitulated in Dr. J. Gwyn Jeffreys' account of the occurrence of similarly bored logs 300 hundred miles up the river Gambia, and his distinct statement, to which I have before alluded,[1] that there is a species which lives in fresh-water; the mention of the subject elicited letters containing even stronger testimony as to the fresh-water habits of the ship-worm. In one of these[2] Arthur Nicols states that *Teredo navalis* is certainly able to endure a long continuance of fresh water, being found at Brisbane, where the river is subject to long-continued freshets. One of these lasted ten days, during which the flood was so powerful that ocean steamers could not get up, yet although the river at ebb-tide is more fresh than salt, the piles have to be protected. In the previous letter[3] a correspondent states that in the Delta of the Irawadi, where for eight months in the year the waters are only slightly brackish or even potable, the large canoes which traverse them are infested with ship-worm, and have to be fired to get rid of them.

This difficulty may, therefore, be regarded as finally removed.

The *Lower Marine Beds* are black sandy clays, and contain oysters and leaves, covered with Polyzoa, and a variety of casts of shells, apparently referable to Bracklesham species; *Callianassa* is also abundant in them, and shore-crabs are met with. These dark beds can be traced from this point for about five miles, where they dip under the beach. They change over and over again, occasionally very abruptly, within short distances, from dark sandy clay to buff or yellow or white sand. Sometimes the dark clay suddenly thins to a mere layer, or is still more frequently only represented by small lenticular patches. The junction between the dark beds and those which overlie them can nearly always be traced by a line of wet which darkens the lower series, even if they also happen to be of white sand. Above these are the *Upper Marine Beds*, generally of pure white, sometimes slightly yellow sand, and inclosing masses of well-rolled shingle. The pebbles are sometimes large, but, of whatever size, they always have a thick white coating,[4] so much so, that frequently only a nucleus of black flint, or not even that, remains. These Eocene pebbles cannot be mistaken for those of the overlying gravel, being far more worn, and well rounded.

These *Lower Marine Beds* contain plant-remains of great interest. Going back to the *Fern Beds*,[5] which are high in the cliffs, the greatest difficulty is experienced in ascertaining how the freshwater beds came to be so completely replaced, within only 100 yards, and upon the same horizon, by marine beds. The frequent landslips, indeed,

[1] Proc. Geol. Association, vol. v. p. 55.

[2] "Nature," May 3rd, 1877. [3] "Nature," April 19th, 1877.

[4] As the Bracklesham flint-pebbles are usually encrusted with *Litharea Websteri*, probably this may explain the "white coating."—Edit. Geol. Mag.

[5] The uppermost of the Bournemouth freshwater series.

that take place here, very seldom allow the section to be seen at all. With difficulty it was cleared, and with the help of Mr. De Wilde, drawings and photographs were taken. The *Fern Beds* and those below them were seen to contract and become very distorted, and to be finally pushed upward and end in a point. A wedge of hardened sand displaces them, and this rapidly thickens or fans out, and forms a cliff 40 feet high, nearly perpendicular, and filled with lumps of clay, the *débris* of broken-up leaf-beds. Under the thin end of this wedge is a mass of whitish sand, belonging to the freshwater beds, and stretching a long way west. The transition does not appear to have been violent or sudden, but rather to mark tidal action. Under this cliff a small ledge contains compressed seeds and carbonised leaf-remains of many kinds—identical with those of Bovey Tracey. Beyond a second landslip, the first cliffs that rise from the beach contain a small patch of beautifully preserved fruits and seeds, which are of great interest. The exact spot is marked by a streamlet, falling over the commencement of the cliff, where it is only about 8 feet high. I mention this stream, as it has been persistent for many years.

At the east corner of Boscombe Chine, about 6 feet above the beach, there is a bed containing branchlets with leaves attached of *Dryandra*, and of a Sequoia-like Conifer. One of the most interesting spots, as well as the most picturesque, perhaps, along the whole coast, is the Honey-Comb Chine.[1] The dark beds near their base are in places so full of the fruit known as *Nipadites*, that after rain a small hand-basket full may be collected in an hour. I also found the base of a magnificently preserved palm-stem, its roots entangling white pipe-clay, inclosed in a bed of sand. The wood was apparently so fresh as to cut easily into slices with a knife, and the fibres separated readily.

One other patch, among many, only need be noticed for its flora, and it occurs but a short distance further on, again being identified by a streamlet. The bed is close to the beach, and is of a cigar-ash colour. It contains, besides much bored-wood, limbs of all sizes of an American Cactus, with the spines adhering, and splendidly preserved branches of a Conifer, common to most beds east of the Pier. With these was a shark's tooth. Other patches contain indistinct leaf-impressions, seeds and pods, casts of Oysters, bored wood, etc.

From this point the cliffs go on with varying strata, and become lower and lower towards the neck of land which connects the promontory of Hengistbury Head with the main land. On the neck itself all the sand has been washed away, and rolled Eocene flints are mixed with the more angular gravel in one shingly mass.

The *Upper Marine Series* is unfossiliferous.

[1] Trespassers are warned off, but the beds are nevertheless well worth examination. The sides, upwards of 100 feet high, are white as sugar, and worn into trellis-like patterns by rain. The ridge separating them, deprived of its gravel capping, and formed of snow-white sand, looks quite Alpine with its sharply-cut peaks and water-worn gulleys, easily magnified by a vivid imagination into chasms and crevasses.

The Head itself contains a separate sequence, the *Hengistbury Head beds.* The uppermost layer is white sand with an orange clay layer at the base. The main mass of the Head is composed of brown clay, to which it owes its preservation. This stiff clay has resisted denudation and the layers of ironstone which it contains, falling into the sea, have formed a protecting barrier.[1] Below the clay is a green sand bed, and lastly we find black, chocolate-coloured, and white sands, belonging to the same Upper Marine Series which we have seen capping the Boscombe Cliff.

The highest beds, above alluded to, I have traced across to the base of High Cliff, where they had already a place assigned to them in the Bracklesham Series.[2]

The Bracklesham Beds.—It is difficult to distinguish these at Alum Bay from the overlying Barton Series. Prof. Prestwich indeed grouped both in one bed, No. 29, but Mr. Fisher[3] has shown that the lower 43 feet form a portion of the Bracklesham Series. The most complete section is at Whitecliff Bay, where almost every bed that has been met with on the main land is represented. The whole group consists of alternations of sand and sandy clay, the clays being more prevalent in the highest member, the sands in the lower. Green grains abound in all the beds. Many of the beds are laminated, being formed of alternations of very thin bands of clay, separated by sandy layers, and contain vegetable matter. The best known localities, and those from whence celebrated collections of fossils have been procured, are Bracklesham or Selsey, Stubbington, and near Bramshaw in the New Forest. At Highcliff, the junction between the Bracklesham and Barton beds is placed by Fisher at the *Nummulina Prestwichiana* bed, 35 feet above the white Hengistbury Head Sand at the base of the cliff. As the Bracklesham Series are at Whitecliff Bay 530 feet thick, we see that there is a probability that the whole of the Marine Series of Bournemouth, with the Hengistbury Head Beds, may be contemporary with them.

The Middle *and so-called* Upper Bagshot Beds *of the London Basin.*—The Middle Bagshots, representing the Bournemouth and Bracklesham beds, have no great extension in the London Basin, and do not exceed forty to sixty feet in thickness. They more resemble the Bournemouth beds than the true Bracklesham series. Their principal development is round Chertsey and Addlestone. They are easily recognized by their sands and clays with green grains, which also distinguish them from the Lower Bagshot beds. They seldom contain fossils, but enough have been found to identify them with Bracklesham.

It appears to me that there is not the slightest reason to suppose that any Upper Bagshot beds are present in the London Basin. The absence of Barton clay, and the identical character of the beds with the Upper Marine beds of Bournemouth, renders it unlikely that

[1] I have made frequent but unavailing search for the leaves marked on the Geol. Survey Map as occurring here, but I have found leaves in the same beds in a brick-pit inland.

[2] Rev. O. Fisher, Q. J. G. S., 1862, vol. xviii. p. 67. [3] Q. J. G.S., 1862, vol. xviii. p. 84.

there is the gap in the sequence there which their present reference to Upper Bagshot implies.[1]

The Bracklesham beds have a very considerable extension in the Paris area, where they are universally admitted to be represented by the well-known and important *Calcaire-Grossier* formation. It is quite otherwise with the supposed Belgian equivalents—the Bruxellien system. In this it is a question of averages, and out of the list of twenty-seven of the most characteristic species cited by Prestwich[2] to support the correlation, twelve, a very large proportion, are Barton; and the Mollusca, as a group, is not sufficiently or purely Bracklesham to warrant belief in so northern a spread of that formation.

The Bovey Tracey Beds.—So ample an account of these and their bibliography is to be found in the reprint from the Philosophical Transactions, part iii. 1862, of the work upon them by Pengelly and Heer, that little can now be added. The peculiarities in the bibliographical history of these deposits are, first, that they were frequently under the notice of scientific men for more than a century, without any distinct vegetable-remains other than wood being found in them; and, secondly, that the fact of Pleistocene deposits overlying them led all writers to presuppose that they were of very recent age. Before, however, Heer and Pengelly had commenced work, Dr. Falconer "made several visits to Bovey,"[3] in some of which he was accompanied by other geologists. "The result was a strong impression that the deposit would be found to belong to the Miocene period." This impression was fully shared in by Pengelly, who was gratified to find it borne out by Heer, when, upon the determination of forty-one species, twenty-two of them new to science, he pronounced the formation to be "decidedly of the Lower Miocene age."[4] Time has, however, completely refuted upon plant evidence the theory that the Bovey beds are Miocene, and unmistakably identified them with the Middle Bagshot of Bournemouth. Upon geological evidence, also, the improbability is apparent of such great deposits being accumulated in a Devonshire valley without any trace of them existing elsewhere; and a theory which brings them into a defined position in the consecutive formations of the country should be a welcome one.

Pengelly's principal section shows a series of beds 115 feet thick, allowing 10 feet for newer deposits, and at p. 14 we find that there are at least 130 feet of underlying beds of the same age (99 feet by actual section, and about 40 feet by estimate, less 10 feet for surface Head or Pleistocene deposits); and we thus have a thickness of some 240 feet. This by no means represents the total thickness, for the bottom has never been reached, and there is also evidence of great denudation. There is besides, a fault, which Pengelly considers to show a vertical displacement of 100 feet, but which may indicate more, to judge from a section on the east side of it, possessing, as it does, only an aggregate of 2 inches of coal instead of 36 feet in a similar depth, so that a great gap may exist between

[1] Mem. Geol. Surv. vol. vi. 1871, p. 333.
[2] Q. J. G. S. vol. xiii. p. 106.
[3] Phil. Trans. part iii. 1862, p. 3.
[4] *l.c.* p. 18.

the two. I by no means, however, endorse Pengelly's idea that the coal is in extensive layers, but should expect to find it only in local patches, of greater or less extent. It is rather difficult to make out what Pengelly believes to be the total thickness of the Bovey Tracey Beds proper. He says, however, that 210 feet is its aggregate thickness, exclusive of Mr. Divett's section, showing, as corroborated by Pengelly, 130 feet of underlying deposit, and of the fault showing at least 100 feet of higher beds. We have thus a total of 440 feet, yet the bottom has never been reached, and much has been denuded. Forbes, in speaking of them, says:[1]—"The present geographical limits of the deposit may have scarcely any relation to its original extension. It is interrupted by considerable faults; and the beds are occasionally disposed at high angles, which have no relation to the present surface-contour; and it seems probable that they may be but a remnant of the original formation, which has been protected from denudation in the Bovey Valley."

The palæontological evidence upon which the Miocene age of these beds has been determined, proves conclusively that they are Middle Eocene and on the same horizon as the beds at Bournemouth, only 80 miles distant. The Oaks, the Laurels, the Figs, apparently all the dicotyledonous leaves, are identical. The Cinnamons of Bovey, thought to be especially characteristic of Miocene, are abundant at Bournemouth. The fruits are so similar that handfuls of *Anona* from each place, if once mixed, could not again be separated. Two Ferns out of three are common to Bournemouth and Bovey, and of these the most characteristic is found equally abundantly at both, and in precisely similar positions. The pinnæ of *Osmunda lignita* are found in blackish shaly clay, spread in layers and mingled with Cactus spines (*Palmacites Dæmonorops*, Heer) and Sequoia. On the other hand, the three small seeds which are supposed to link Bovey with Hempstead are insignificant, and indeed are not confined to the Hempstead Beds. If the Bovey Beds are Miocene, the Bournemouth Beds must also be Miocene.

Osmunda bromeliæfolia of the Philippine Isles. Indistinguishable from *O. lignita*.[2]

Having so much reason to believe that the series is contemporaneous with the Eocene at Bournemouth, we see that this silted-up lake lies in the direction whence the Great Eocene river came, and must either have been in its direct course, or in that of one of its affluents. Lyell's account of the imbedding of plant-remains in the Slave Lake is so curiously like what must have happened here, that parts of it are extracted.

[1] Quart. Journ. Geol. Soc. vol. ix.

[2] From the Royal Herbarium, Kew. *Plenasium bromeliæfolium*, Presl., Ettingshausen's Farnkräuter der Jetztwelt, p. 152, fig. 66, 67; pl. 80, fig. 1. Isle of Luzon.

"In Slave Lake, in particular, which is 200 miles long, the quantity of drift timber brought down annually is enormous." The trees become water-logged and sink, and "the trunks gradually decay, until they are converted into a blackish-brown substance resembling peat, but which still retains more or less of the fibrous structure of the wood; and layers of this often alternate with layers of clay and sand." The banks have "a remarkable horizontal slaty structure," and along the Mackenzie "display almost everywhere horizontal beds of woody coal, alternating with bituminous clay, gravel, sand, and friable sandstone." . . . "The Slave Lake itself must, in process of time, be filled up by the matters daily conveyed into it by the Slave River." [Principles of Geology, 1868, 10th edit., vol. ii. p. 526.]

To believe that this huge fragment of a large deposit belongs to the Miocene, we have to suppose that it was deposited and all, except this patch, denuded at a period when we have no record of agents existing in our country capable of doing the one or the other, and this in spite of lithological and palæontological evidence which directly connects them with a similar mass of strata not 80 miles distant.

III.—On the Metamorphic and Intrusive Rocks of Tyrone.[1]

By J. Nolan, M.R.I.A., etc.;
of H.M. Geological Survey of Ireland.

The rocks I propose to describe in this paper belong to that great metamorphic series which occupies so large a portion of the north of Ireland, extending over most of the counties Tyrone, Londonderry, and Donegal. For the present I shall confine my observations principally to that portion of them situated about the central parts of Tyrone, from the vicinity of Omagh eastwards and north-eastwards towards Slieve Gallion. This district has been already ably described by General Portlock in his "Geological Report on Londonderry and parts of Tyrone and Fermanagh"; but as, during the progress of my work for the Geological Survey, I have had opportunities for a very detailed examination of it, I beg, briefly, to offer some further remarks and conclusions.

The rocks in the district may be thus classified:—

First.—Schist and Gneiss.

Secondly.—Green metamorphic rock, generally hornblendic or pyroxenic, passing in some parts into schist, and in others into granite.

Thirdly.—Quartz Porphyry and Granite — metamorphic and intrusive.

First.—*Schist and Gneiss.*—Little requires to be noticed of these rocks, as in this district they present but few special characteristics. They occupy a hilly tract of country, extending from near Carrick-

[1] This paper is published by permission of the Director of the Geological Survey of Ireland, and of the Director-General. It was read before the British Association in Dublin, August, 1878.

more north-eastwards to Fir Mountain, having a width of from three to four miles at the greatest, and terminating at both ends among the green metamorphic rocks presently to be described, in which, indeed, they may be considered as forming a huge lenticular mass. The prevailing character is a coarse massive gneiss passing into schist, generally micaceous, and often containing some hornblende. Close to the junction with the green metamorphic rocks just alluded to, the foliation is less strongly marked, while the texture is more crystalline, and much hornblende appears, as if passing gradually into that rock. Remarkable examples of this may be seen at Fir Mountain, and at Lissan, in the stream forming the county boundary. In the former locality, we find at the base of the hill, micaceous schists and well-foliated gneiss, succeeded by a coarser quality, till at the summit we have massive rocks, in which all traces of foliation seem nearly obliterated, approaching so closely to the hornblendic type that no exact line of division is at all possible. The stream section, north of Lissan demesne, exposes similar rocks, which are more quartzose, and change into granite and syenite. From these observations it would appear that the schistose and amorphous green rocks are but parts of one system, the varieties being due either to differences in the chemical composition of the original rocks, aided, probably, by conditions of greater intensity of heat and pressure, or perhaps, that the more crystalline parts were the result of re-metamorphism. That some such action has taken place over that part of the district at least, I shall endeavour to show subsequently.

Secondly.—*Green metamorphic rocks, generally hornblendic or pyroxenic.*—These, as has been remarked, occupy the country around the gneiss series just described. The most prevailing kind consists of an aggregate of plagioclase felspar, which is often labradorite, with hornblende, or pyroxene, or both, developing in some places into largely crystalline hypersthenite, in others becoming more finely crystalline, passing into a compact greenish or bluish variety. Free quartz, too, often occurs, sometimes in grains scarcely perceptible, but in other places developing into great crystalline blebs, converting the rock into a coarse syenite.[1] Examples of this may be observed in the hills north of Pomeroy, where, at the base, the hornblendic rock with a little quartz is seen, which mineral increases in the space of a few yards to great crystals, that weather out in warty excrescences, giving to the rock, as Portlock remarks, "a peculiar mechanical aspect."

In other localities the compact varieties become highly felspathic, and pink felspar (orthoclase) appears, with quartz, until a corase elvanite or quartz porphyry is produced, which usually contains mica and passes into granite, or syenitic granite by the addition of hornblende.

That the green metamorphic rocks thus pass gradually into granite,

[1] I use the term syenite in the same sense as it is used in Jukes's Student's Manual of Geology, viz. "A crystalline granular aggregate of felspar, hornblende, and quartz."

appears to have been the opinion of the late Sir Richard Griffith and General Portlock. Thus, at p. 60 of his "Geological Report, etc.," we find the latter author quoting the former—"Slieve Gallion mountain is composed of granite, syenitic granite, syenitic greenstone, and greenstone, and the same varieties of rock, apparently graduating into each other, occupy the parishes of Lissan and Kildress"; and at p. 94, he himself states that "there are so many gradations of change, from the rock which appears decidedly granitic into hornblendic rocks on the one hand, and into others which are little more than schists, in which the constituents have been blended together and the stratification obliterated, that the mind seems forced to consider the whole, even to the granite, as metamorphic."

In other parts of the green rock basic minerals prevail, and it becomes coarse diorite, diallage, or hypersthenite. One of the best localities where these changes may be seen is at Termon Rock, near Carrickmore. The massive crags which rise abruptly over the flat through which the railway runs are diorites, traversed in every direction by veins of epidote; and at the Glebe of Athenree, one mile to the east, the diorite is replaced by diallage or hypersthenite; while at the "Scalp," two miles to the north-east, a more largely crystalline variety occurs. At all these places the felspar is, as we might expect, labradorite, yet at Oritor, near Cookstown, there is a massive rock in which hypersthene is associated with orthoclase.

In close proximity even to the largely crystalline rocks sudden variations in texture are not uncommon. These are well shown at the locality just mentioned, where, in the same mass, one part is compact, while the rest is crystalline often to a great degree. In some cases, too, hypersthene appears in one part of the mass, while the rest is compact, and traversed by veins consisting of a mixture of quartz and orthoclase. Again, the compact variety often presents the appearance of a dyke traversing the more crystalline portion. In one case of this kind a lenticular dyke-like rock was traced over a distance of thirty yards, and looked very much like basalt. In it, however, white crystals of orthoclase were observed.

These compact dykes and veins traversing the more crystalline portions seem to be analogous to those of fine-grained granite rock which may be seen cutting across the granite in the neighbourhood of Dublin, and have been called *eurites* by the late Professor Jukes. Such veins he regards as portions of the same magma as the granite, proceeding from the parts still in fusion, and forced into cracks or fissures in the partially consolidated upper portions, and the same explanation may answer as well for the compact dyke-like veins just described.

Another variety of these compact and finely-crystalline rocks is one full of cells, usually filled with calcite, or, though rarely, chalcedony. These may be seen at Slieve Gallion, at Drumnakilly near Omagh, and at several intermediate localities. Some parts, from the number and size of the cells, suggesting great disengagement of elastic fluids, present such appearances of a volcanic nature that one is at first inclined to consider them as such, yet, on further examination, there is no evidence of extrusion, the rock changing by the gradual disappearance of the cavities into the ordinary hornblendic close-grained variety.

The passages from these varieties into schistose rocks are also very remarkable. They not only occur in the vicinity of the schist series, but everywhere throughout the mass, no considerable tract of which, indeed, is without some trace of foliation. Thus, at Termon Rock, which is mostly composed of coarse diorite, foliation was observed in the more finely crystalline portions, associated with a variety, which, from its close texture, has much the look of an indurated or highly altered slate, full of strings and ramifying veins of serpentine; and to the north-east of Omagh, west of the road to Mountfield, similar schistoid rocks, also abounding with serpentine, may be seen.

A very interesting series is met with at Beaghbeg, some six miles north of Pomeroy. Here, within a small area, are diallage and quartz-porphyry, having between them finely crystalline and compact rocks. Some of these latter have minute scattered prisms of hornblende in a felspathic-looking base, and change into partially foliated rocks of porcelainic appearance, with numerous strings and veins of quartz. Close to this, on the north-west, are chloritic aud talcose schists, and schist breccias, containing pieces of red iron jasper and green flinty-looking rocks with quartz grains like altered felstones, or perhaps very quartzose grits. These latter were again noticed at Creggan, four miles to the south-west, but among the finely-crystalline hornblendic series. They have all the appearance of metamorphosed conglomerates, and still further confirm the evidence as to the original sedimentary character of these rocks.

Thirdly.—*Quartz, Porphyry, Granite, and Syenite.*—It has been before remarked, that the compact varieties of the green metamorphic rock frequently lose all trace of hornblende, and become felspathic. The base in these cases is usually of a light green or bluish, changing to a pink or reddish grey colour. This occurs very gradually—first there appear a few spots of a pink or reddish shade, these then extend and form the prevailing tint of the base, and some quartz appears. Crystals of flesh-coloured orthoclase and a light olive-green felspar that seems to be oligoclase, are now observed, the blebs of quartz increasing in size and quantity, with an admixture of dark green mica of resinous lustre occurring in hexagonal plates. We thus get a quartz-porphyry—a rock having all the constituents of granite, differing only in the disposition of the silica, which, as just remarked, is in individual crystals, and does not form the base. It is easy to see that a rock of this kind can readily pass into true granite, requiring but such an increase in temperature as to keep the silica in solution while the other minerals have crystallized out, and, accordingly, we find that in many parts of this district the quartz-porphyry does pass into granite. A very remarkable example may be seen at Mullanamore Bridge, north of Carrickmore. The porphyry was observed in the stream a little above the bridge, close to it is a rock which it is impossible to refer with certainty to either class, while immediately at the bridge is typical granite. At all these places the rock has the same general character of a coarse quartzose mass with pink felspar and green mica, except that to the north the base is felspathic, while to the south it is siliceous, and has the granular character of granite. Similar observations were made in a quarry a little east of this, and in some other localities, particularly at Slieve Gallion, where several sections exhibit this change from porphyry into granite.

At the summit of Glenarudden Mountain, the porphyry is succeeded by a rock having a compact base of a greenish or greyish colour, with, occasionally, spots of red or flesh-coloured felspar, and a little diffused hornblende. Towards the north this latter mineral increases in quantity, and quartz appears; giving place, however, to a rock devoid of that mineral, and in which the hornblende is replaced by pyroxene, with some serpentine. This, again, is succeeded by and passes into the same kind of compact felspathic green rock, and ultimately into the porphyry. In the vicinity, at a stream called the White Water, the latter rock has a decided schistose character, approximating it more closely to the nature of a metamorphic than of an intrusive igneous rock.

Another remarkable variety may be seen at Carrickmore, at the Glebe of Athenree, and at some other localities in the adjoining little glen of Tremogue. This is a finely-crystalline mixture of quartz and felspar, with a small proportion of mica, some of which is talcose-looking, though for the most part it occurs in small white silvery scales, probably lepidolite. It is described by Portlock as a granite, though it may perhaps be more properly classed among the elvanites. As the exposures of this rock occur on a regular line bearing north-eastwards, it might at first appear to be an intrusive dyke in the metamorphic rocks, but this view is not borne out by an examination of its relations to those rocks. At the several localities where sections were observed, they seem to graduate into each other, the dark-green micro-crystalline hornblendic rock becoming felspathic and light-coloured, in the vicinity of the elvanite, passing insensibly into it, though in one place it seems to penetrate it as a dyke. It is impossible to say whether the elvanite might not have been originally a bed of fine quartzose grit, or perhaps an intrusive dyke in the old sedimentary rocks, fused in with them when the whole series were metamorphosed.

The granite of this district is very variable in composition. In general, it contains the same minerals as the porphyry, but in some places the mica is replaced by talc or chlorite. Of secondary minerals, carbonate of lime is the most prevalent, and at Limehill, near Pomeroy, it occurs in such quantity, that in one part the quartz altogether disappears, and the resultant is a curious mixture of pink felspar and carbonate of lime; so that it has been burned, though with little success, for agricultural purposes.

Changes from the granite into the green hornblendic rocks, through syenite, have already been noticed. Hornblende, indeed, is pretty generally disseminated through the granite, and in some parts is in about equal proportion with the mica, forming hornblendic or syenitic granite. This again passes into a variety devoid of mica, the felspar changing to a greenish colour, and ultimately into the quartzless hornblendic rock. These changes, as before mentioned, are well seen at Slieve Gallion, and also at the hills called Bardahessiagh, and Craighballyharky, north of Pomeroy, where instances occur, in which the granitic and hornblendic varieties are so blended in the same rock-mass, that it is quite impossible to distinguish them.

Granite as an Eruptive Rock.—When the maximum of metamorphism is reached in the complete fusion of rock and conversion into crystalline granite, we may expect to find that at some places such a mass has been intrusive, and, accordingly, there are few areas occupied by metamorphic granite, in which it has not been evidently intrusive at some parts. Thus, in the granite of Newry, the great mass of which I believe to be of metamorphic origin, parts are certainly intrusive, instances of which will be found detailed in the Geological Survey Memoirs descriptive of that part of the country. So, in this district too, the granite has all the appearance of having been intrusive at some parts. Thus, at Drumduff, near Beragh, close to the margin of that rock, the sandstones are indurated, and have an unusually high dip; but by far the best evidence is to be seen at Aghnagreggan Bridge, near Carrickmore. There the sandstones can be observed in actual contact with the granite, they are highly disturbed and semi-vitrified, being converted into yellowish quartzite, leaving little room for doubt but that the granite has been intruded through them. It cannot be regarded as being due to metamorphism of the sandstone, for in the immediate vicinity beds were found quite unaltered. This could not be the case if this part of the Old Red Sandstone had undergone so complete a change as a conversion into granite. A great extent of rock would be indurated, then foliated and altered into coarse gneiss, which, becoming more massive and crystalline, would ultimately pass into granite. As no such gradation was anywhere observed in this district, no change in the sandstones being effected, except on those in contact, which, as just now remarked, have been partially vitrified and altered in colour, as happens where masses of molten rock have been protruded through sedimentary strata, we may justly conclude that a similar action has taken place here, and that some of the granite has been intrusive. If this be so, then, we have proof that the granite is newer than the earlier part of the Old Red Sandstone period, while the mass of the schists and other metamorphic rocks with which it is associated, and into which it appears to graduate, are certainly older, being probably of Lower Silurian age, coeval with those in the West of Ireland. This apparent difficulty is, however, easily explained, if we suppose the granite, and perhaps some of the other highly crystalline rocks, to be the result of re-metamorphism. The depression, which took place during the period when the great series of sandstones and conglomerates—which even now have a thickness of upwards of 10,000 feet—were deposited, must have sunk the underlying metamorphic rocks to such an immense depth that their lowest portions were completely fused and became intrusive. This latter action must have taken place prior to the commencement of the Carboniferous period, as, at Slieve Gallion, the basal beds of that formation rest upon the granite, and are, in fact, almost altogether made up of its *débris*.

That metamorphic action continued to affect the rocks of this district at various periods up to that of the Upper Old Red Sandstone, seems to have been the opinion of General Portlock, and he regards the granite as a result of the metamorphism of rocks of the latter formation. Indeed, if his view be correct, the formation of the granite should be regarded as of post-Carboniferous age, as it is really the lowest beds of that formation—the red sandstones and quartzose conglomerates—that he calls Upper Old Red Sandstone. The sections he describes at Slieve Gallion, as exhibiting changes from red sandstone through partially altered rocks containing felspar, into granite, have been just referred to, and it has been shown that these appearances are due to the fact, that the sandstones in proximity to the granite are almost altogether made up of its fragments, in many cases, too, of crystals that have undergone but slight attrition, so that the distinction between the crystalline and the derivate rock is often a matter of considerable difficulty.

On the whole, therefore, there appear to be good grounds to establish the conclusion, that we have in Ireland an intrusive granite of Old Red Sandstone age. Hitherto most of the granite of this country has been considered to be of older date except that of Mourne and the elvanites of Carlingford, which are post-Carboniferous.[1] The discovery of granite of an intermediate period is, however, but what we might expect, as we have no reason to suppose but that it was formed during every period, even at the present day, when, as Professor Jukes remarks—"Granite must be forming now wherever molten rock of the proper chemical composition is cooling under the requisite physical conditions;" and we may expect that the further investigation is extended, the better will we be able to assign to their respective ages in the history of our earth, a class of rocks, which, not very long since, were believed to be essentially primeval and antecedent to all others.

Note.—Since the above was written, Mr. Kinahan's book on the "Geology of Ireland" has appeared, in which the rocks here described as Old Red Sandstone are classed with the Silurian system. Without expressing any opinion on this question, I may remark that it does not at all alter the geological position of these beds, as they are referred to a later age than any of the generally recognized Upper Silurian rocks—while the era of intrusion of the granite must still be regarded as of post-Silurian and pre-Carboniferous age.

[1] Mr. Symes describes an intrusive granite near Westport as "of older date than the Upper Silurian period," but there does not seem to be any evidence to fix its age more definitely. See Geol. Survey Memoir to accompany Sheets 83 and 84.

IV.—Notes on the Bivalves contained in the Gilbertson Collection, British Museum, and Figured in Phillips's "Geology of Yorkshire."

By R. Etheridge, Jun., F.G.S.;
of the British Museum.

By far the larger proportion of the Carboniferous fossils described and figured by the late Professor John Phillips, F.R.S., in the second volume of his "Illustrations of the Geology of Yorkshire," and published in 1836, are contained in the collection of the late Mr. Gilbertson, of Clitheroe, now deposited in the Geological Department of the British Museum. The early date of publication of this work renders the collection described in it one of the most important, next to those of Sowerby, Ure, Martin, and one or two others, to students not only of British, but equally so of Continental Carboniferous Palæontology. Unfortunately the descriptions of Prof. Phillips are so abbreviated and unsatisfactory, and the figures in many instances so meagre, that it is with great difficulty anything like an accurate determination of a species can be made by the aid of them. Under these circumstances the following notes made directly from the type specimens will probably be found of use; it would, however, be far more satisfactory to have the specimens refigured. For convenience sake I shall commence with those composing plate vi., and then take the others composing plate v.

1. *Pinna inflata*, Phillips sp. (p. 211, t. 6, f. 1).

This, as already pointed out by Mr. Davidson,[1] is *Productus striatus*, Fischer. The Gilbertson Collection contains three specimens, but not the figured one, so far as we can ascertain, although it is so stated by Prof. Phillips.

2. *Pinna costata*, Phillips sp. (p. 211, t. 6, f. 2).

I can see little or no difference between this and the ordinary *Pinna flabelliformis*, Martin; indeed this appears to have struck the author himself, for he says, "This is probably the species figured by Martin under the name of *Pinna flabelliformis*, and *P. nuda*." Prof. M'Coy has so placed it with a note of interrogation.[2]

3. *Inoceramus vetustus*, Sowerby (Phillips, p. 211, t. 6, f. 3).

The Gilbertson Collection possesses a specimen which may be one of the types of this species, it is larger than fig. 3, and is not in quite such a perfect state of preservation as that is represented, but unless there is a specimen in the Collection of the Yorkshire Philosophical Society bearing a greater resemblance, this must be the figured form. The original of fig. 4 I cannot trace.

4. *Avicula cycloptera*, Phillips sp. (p. 211, t. 6, f. 5).

A peculiar and well-marked species. The type is the only example in the Collection. It is on a weathered limestone surface, and is scarcely so well preserved as the figure represents.

5. *Avicula tessellata*, Phillips sp. (p. 211, t. 6, f. 6).

This species is referred by Professor John Morris[3] to the genus *Aviculopecten*. I have not seen the characters of the hinge. The Gilbertson Collection contains only the figured example.

6. *Pecten granosus*, Sowerby (Phillips, p. 213, t. 6, f. 7).

This specimen is not in the Gilbertson Collection.

[1] Mon. Brit. Carb. Brachiopoda, 1861, pt. 5, p. 139.

[2] Brit. Pal. Foss. p. 498.

[3] Catalogue, 2nd ed., 1854, p. 166.

7. *Avicula radiata*, Phillips sp. (p. 211, t. 6, f. 8).

The figure of this species in no way does the specimen justice. The number of radiating ribs, which are numerous, are not distinctly shown, neither is the full extent of the shell. The posterior wing appears characteristic. By Morris it is placed in *Aviculopecten*.[1]

8. *Gervillia squamosa*, Phillips sp. (p. 212, t. 6, f. 9).

The broad squamose ridges render this species a particularly well-marked form. The vacant space within outline on the left of the figure should represent the internal cast from which the shell has been removed. The lower vacuity is matrix covering up the ventral portions of the valve. It is the *Avicula squamosa* of Morris.[2]

9. *Gervillia laminosa*, Phillips sp. (p. 212, t. 6, f. 10 and 11).

Here, again, the figure does not fully represent the original. The shell is in form quite a *Pteronites*, only the umbonal slope is too pronounced. There is not that great declivity between the body of the shell and the posterior and anterior wings shown in the figure. Prof. Morris refers the species to *Avicula*.[3]

10. *Gervillia lunulata*, Phillips sp. (p. 211, t. 6, f. 12).

The type is a beautifully preserved shell in limestone. Prof. Phillips's figure has been a little restored about the beaks and posterior margin. There is another large example, without any trace of shell remaining, measuring as much as four inches and a half in its longest diameter by two and a half. And yet another specimen nearly as large. The species is placed in *Avicula* by Prof. Morris.[4]

11. *Gervillia inconspicua*, Phillips sp. (p. 212, t. 6, f. 13).

Not in the Gilbertson Collection.

12. *Perna?* Phillips sp. (t. 6, f. 14).

This is the internal cast of a Myaliniform shell in limestone, without any characters whatever by which it can be identified.

13. *Pecten ellipticus*, Phillips sp. (p. 212, t. 6, f. 15).

The hinge characters are exceedingly well shown in this cast, although not illustrated in the figure. It is an *Entolium*, and not very far removed from *E. Sowerbii*, M'Coy. It is the *Aviculopecten ellipticus* of Morris.[1]

14. *Pecten hemisphericus*, Phillips sp. (p. 212, t. 6, f. 16).

The shell which is marked in the Collection as the type of this species has either been injured since the figure was drawn, or the latter was somewhat restored. It is deficient around the ventral margin.

15. *Pecten dissimilis*, Phillips sp. (p. 212, t. 6, f. 17 and 19).

I am only able to satisfactorily recognize the specimen from which fig. 17 has been taken, and I must for the present refrain from expressing any opinion on the identity, or otherwise, of *Aviculopecten dissimilis*, Fleming, and *A. dissimilis*, Phill. The subject of fig. 17 has remarkably close and concentric lines covering the whole surface of the valve.

16. *Pecten stellaris*, Phillips sp. (p. 212, t. 6, f. 18).

The ribs in the type are of a much less prominent nature than shown in Phillips's figure, and there are three distant concentric lamellæ. This and the *Avicula tessellata* are very much alike in the nature of the ribbing, only in *P. stellaris* the ribs are much more numerous, the anterior ear is divided off from the body of the shell, and there is no obliquity, as in *Avicula tessellata*.

17. *Pecten arenosus*, Phillips sp. (p. 212, t. 6, f. 20).

There is no shell at all resembling this figure in the Gilbertson Collection. From the appearance of the figure I should imagine it represents an imperfect shell.

18. *Pecten plicatus*, J. de C. Sowerby (Phillips, p. 212, t. 6, f. 21).

I have compared this with Sowerby's type and find that it corresponds in every particular, except that in the type the ribs are finer and more numerous. In the Phillipsian shell the posterior wing is deficient, it really runs out to an extended

[1] Cat. Brit. Foss. 2nd ed. p. 165. [2] *Ibid*, p. 162. [3] *Ibid*, p. 162.
[4] *Ibid*, p. 162. [5] Catalogue, 2nd ed. 1854, p. 164.

point when the valve is perfect. Phillips described his shell as, "Ears without radiating ribs?" I find, however, that this doubt on Prof. Phillips's part arose from the decorticated nature of the ear-surface of his specimen; there are distinct traces of radiating ridges. Sowerby, in his description, says, "smooth striæ,"[1] and Phillips, "nearly smooth radiating ribs," but there can be no doubt, on a careful examination, that both Sowerby's original, and the specimen referred to this species by Phillips, were minutely and strongly decussated by close, concentric, frilled imbrications, now in a great measure worn off.

19. *Pecten anisotus*, Phillips sp. (p. 212, t. 6, f. 22).

I have compared the type of this species with the specimens upon which I founded the provisional species of *Aviculopecten subanisotus*,[2] and I find, as I then anticipated, that they are one and the same. The posterior ear as represented in Phillips's figure is incorrect; in the specimen it is broken away, in the perfect shell the valve expands gradually into it, and there is no notch as shown in the figure referred to.

20. *Plagiostoma* (Phillips, t. 6, f. 23).

Probably an *Aviculopecten*, although I cannot find the specimen.

21. *Pecten interstitialis*, Phillips sp. (p. 212, t. 6, f. 24).

The figured specimen is not in the Gilbertson Collection, although there are several specimens so labelled, with very few and coarse ribs, resembling in this respect *Aviculopecten Murchisoni*, M'Coy.[3]

22. *Avicula sublobata*, Phillips sp. (p. 211, t. 6, f. 25).

The type is not in the Gilbertson Collection. I cannot therefore institute a direct comparison with those shells I described[4] some time ago, under this name, showing colour bands.

23. *Pecten deornatus*, Phillips sp. (p. 213, t. 6, f. 26).

Not in the Gilbertson Collection.

24. *Pecten simplex*, Phillips sp. (p. 212, t. 6, f. 27).

The specimen appears to have been mislaid.

25. *Pecten fimbriatus*, Phillips sp. (p. 213, t. 6, f. 28).

The type is not in the Gilbertson Collection.

26. *Corbula? senilis*, Phillips sp. (p. 209, t. 5, f. 1).

Not in the Gilbertson Collection.

27. *Sanguinolaria? angustata*, Phillips sp. (p. 208, t. 5, f. 2).

In a very imperfect state of preservation. This was made by M'Coy the type of his genus *Sanguinolites*,[5] but the specimen is utterly useless for type-purposes.

28–32. *Sanguinolaria tumida*, Phillips sp. (p. 209, t. 5, f. 3).

S. arcuata, Phill. (p. 209, t. 5, f. 4), *S. sulcata*, Phillips sp. (p. 209, t. 5, f. 5), *Solemya primæva*, Phillips sp. (p. 209, t. 5, f. 6), and *Venus elliptica*, Phillips sp. (p. 209, t. 5, f. 7), are in other collections.

33. *Venus parallela*, Phillips sp. (p. 209, t. 5, f. 8).

A much worn little shell, but possessing strong concentric prominent ridges when in the perfect condition. It is placed in the genus *Cypricardia* by Prof. L. G. de Koninck.[6]

34. *Isocardia oblonga*, J. de C. Sowerby (Phillips, p. 209, t. 5, f. 9).

A very good example with the outer shelly layer removed. The valves are in apposition, the left moved a little out of place. I have compared this with Sowerby's type, and find that it agrees intimately.

35. *Cypricardia rhombea*, Phillips sp. (p. 209, t. 5, f. 10).

The type of this species does not correspond with the shell I have been in the habit of calling by this name, or have usually seen so labelled in collections.

[1] Min. Con. vol. vi. p. 144.
[2] Mems. Geol. Survey Scot., Expl. 31.
[3] Synopsis Carb. Limestone Foss. Ireland, 1844, t. 18, f. 3.
[4] Geol. Mag. 1876, Dec. II. Vol. III. p. 151.
[5] Synop. Carb. Limestone Foss. Ireland, p. 48.
[6] Descrip. Anim. Foss. Tert. Carb. Belgique, p. 97.

Phillips's species is a somewhat elongated shell, and has been fairly portrayed, so far as the general characters go, by Prof. de Koninck.[1]

36. *Nucula luciniformis*, Phillips sp. (p. 210, t. 5, f. 11).

The concentric striæ are exceedingly fine in this species, the beaks quite close together, and the escutcheon linear, and little developed.

37. *Nucula brevirostris*, Phillips sp. (p. 210, t. 5, f. 11a).

Not in the Gilbertson Collection.

38. *Lucina? laminata*, Phillips sp. (p. 209, t. 5, f. 12).

This is an Edmondia-like shell with close concentric imbricating laminæ. I cannot conceive what has led Prof. de Koninck[2] to unite this species with *Modiola squamifera*, Phillips, for there could not be two more dissimilar shells, more especially as he had previously placed[3] *L.? laminata* in the genus *Cardinia*.

39. *Isocardia? axiniformis*, Phillips sp. (p. 209, t. 5, f. 13).

Not in the Gilbertson Collection.

40. *Nucula cuneata*, Phillips sp. (p. 210, t. 5, f. 14).

The figure of this species is much enlarged. It has no appearance of a *Nucula*, but I suspect it is very much more nearly allied to *Pleurophorus*, King. The posterior radiating striæ are quite apparent.

41. *Nucula tumida*, Phillips sp. (p. 210, t. 5, f. 15).

As pointed out by Prof. M'Coy,[4] this is the *N. gibbosa*, Fleming, under which name the shell is now universally known.

42. *Nucula undulata*, Phillips sp. (p. 210, t. 5, f. 16).

The posterior end of this shell is produced, and when perfect is obtusely pointed. In the figure it is too rounded and should have been represented as broken off. It belongs to the same group of Palæozoic Nuculidæ as *N. lævirostrum*, Portlock.

43. *Nucula claviformis*, Phillips, non Sow. (p. 210, t. 5, f. 17).

Identical with *Leda* or *Nuculana attenuata*, Fleming. The specimens with which Phillips worked were contained in the Collection of the Yorkshire Philosophical Society, the Gilbertson Collection, and that of the Natural History Society of Newcastle. Phillips usually appears to have first indicated after the name of each species that collection in which his type was placed, and following that rule, the type of this species would be in the Cabinet of the Yorkshire Society, but the Gilbertson Collection contains one so like the figure that I cannot but regard it as the original of his *N. claviformis*.

44. *Isocardia? unioniformis*, Phillips sp. (p. 209, t. 5, f. 18).

The original specimen is in a very bad state of preservation. The species is the type of Prof. de Koninck's genus *Edmondia*.[5]

45. *Cucullæa obtusa*, Phillips sp. (p. 210, t. 5, f. 19).

Although marked in the usual way by Phillips as being in the Gilbertson Collection, I am unable to find the type.

46. *Cucullæa arguta*, Phillips sp. (p. 210, t. 5, f. 20).

Phillips remarks that his shell is restored at the ends, and there is in the collection such a specimen wanting a portion of the posterior end, otherwise it is in a very good state of preservation, and is clearly the specimen from which Phillips's figure was drawn. By the latter the species was referred to *Cucullæa*, and by Prof. de Koninck to *Arca*,[6] but whatever may be the character of the shell to which Prof. de Koninck has applied this name, that figured in the "Geology of Yorkshire" belongs to neither of these genera, but possesses the prominent concentric ridges, split on the anterior end, the anterior sinus, and well-developed posterior slope of that group of shells to which Prof. M'Coy, in 1852, applied his previously enunciated name of *Leptodomus*. Accepting the specimen in question in the Gilbertson Collection as the type, I feel sure that it is to this group it will have to be referred, and neither to *Cucullæa* nor *Arca*.

[1] Descrip. Anim. Foss. Tert. Carb. Belgique, Atlas, t. 1, f. 15, a. c.
[2] *Loc. cit.* p. 92. [3] *Ibid*, p. 78. [4] Brit. Pal. Foss. p. 512.
[5] Descrip. Anim. Foss. Terr. Carb. Belgique, p. 66. [6] *Loc. cit.* p. 116.

47. *Modiola lingualis*, Phillips sp. (p. 209, t. 5, f. 21).
The type of this species is not preserved in the Gilbertson Collection, but there are specimens of the shell to which I gave the name of *Modiola lithodomoides*, which may be only the full-grown condition of *M. lingualis*.

48. *Modiola squamifera*, Phillips sp. (p. 209, t. 5, f. 22).
An exceedingly well-marked shell, distinguished by its broad flat lamellæ; the posterior wing is small, although it is not entirely preserved, and the dorsal margin in Phillips's figure is too decidedly marked. This species belongs to a peculiar group of Carboniferous Mytiliform shells of the hinge character of which we at present know little. By Prof. de Koninck it has been identified[1] with a Belgian shell, which he places in the genus *Cypricardia;* but judging from the respective figures, I should be inclined to pause before uniting the two.

49. *Modiola granulosa*, Phillips sp. (p. 210, t. 5, f. 23).
Not in the Gilbertson Collection.

50. *Modiola elongata*, Phillips sp. (p. 210, t. 5, f. 24).
If the figure is a correct representation of the original, the specimen is not in the Collection.

51. *Cypricardia glabrata*, Phillips sp. (p. 209, t. 5, f. 25).
Not in the Gilbertson Collection.

52. *Pleurorhynchus Hibernicus*, J. Sowerby (Phillips, p. 210, t. 5, f. 26).
Phillips's type of this species is not in the Gilbertson Collection.

53. *Pleurorhynchus minax*, Phillips (p. 210, t. 5, f. 27).
Phillips remarks that the lower figure of Sowerby's *Cardium aliforme*[2] is probably his species, and this view has been adopted by Prof. Morris.[3] On the other hand, Professors de Koninck[4] and M'Coy[5] wholly unite *P. aliforme* and *P. minax*. After a very careful and lengthened comparison of the types of both Sowerby and Phillips, I have to express my complete adherence to the views of these authors so far, leaving out of the question, for the present, the question of the Devonian *P. minax*.[6] Extreme care should be taken in describing the surface characters in this group of shells, for I find that the shelly matter was of considerable thickness, and the various layers each possessed its own style of ornament. This has been noticed to a certain extent by Prof. M'Coy;[7] when perfect, *Conocardium* (*Pleurorhynchus*) *aliforme* has the valleys between the radiating ribs crowded with close undulating laminæ resembling those seen on the surface of *Spiriferina laminosa*.

54. *Pleurorhynchus elongatus*, J. Sowerby (Phillips, p. 211, t. 5, f. 28).
An exceedingly well-marked and distinct form; it has been shown by Prof. de Koninck, who is followed by M'Coy, to be only a synonym of *Conocardium rostratum*, Martin.[8] I have compared Sowerby's figured specimen, which was given to him by Mr. Martin, with Phillips's shell, and find them to agree.

55. *Pleurorhynchus armatus*, Phillips sp. (p. 211, t. 5, f. 29).
This specimen is not in the Gilbertson Collection, but I have little doubt that Prof. de Koninck is correct in referring[9] it to *Conocardium* (*Pl.*) *aliforme*, Sow.

56. *Pleurorhynchus trigonalis*, Phillips sp. (p. 211, t. 5, f. 30–32).
I have examined in detail the only specimen of this species in the Gilbertson Collection, and which represents figs. 30 and 32 of the above plate, but somewhat on an enlarged scale. Prof. de Koninck has referred[10] this species to *C. Hibernicum*, Sowerby; in this I agree with him, as I believe it to be only the young form of the latter.

57. *Unknown genus*, Phillips (t. 5, f. 33).
Not in the Gilbertson Collection.

[1] *Loc. cit.* p. 92, t. 3, f. 11.
[2] Min. Con. t. 552.
[3] Catalogue, 2nd ed. p. 195.
[4] *Loc. cit.* p. 83.
[5] Brit. Pal. Foss. p. 516.
[6] Pal. Foss. Cornwall and Devon.
[7] *Loc. cit.* p. 517.
[8] *Arcites*, Pet. Derb. t. 44, f. 6.
[9] *Loc. cit.* p. 83.
[10] *Ibid*, p. 85.

V.—Post-Tertiary Geology of Cornwall.[1]

By W. A. E. Ussher, F.G.S.

Part III.—The Raised Beaches and Associated Deposits of the Cornish Coast.

THE following observations of the Cornish Cliffs are given in order, proceeding round the coast from Plymouth. The numbers and letters have been prefixed to facilitate subsequent reference.

1. Mount Edgecombe, near Plymouth.

a. De la Beche (Geological Manual, p. 159) mentions the occurrence of rolled shingles, covered by fragments of slate and red sandstone near Redding Point; the height of the deposit is not given.

b. Near Mount Edgecumbe Obelisk I noticed brown and reddish coarse-grained sand filling an inequality in the limestone at about 30 feet above the river; this is probably a trace of contemporaneous deposition with the Hoe Raised Beach.

2. Looe Island. Mr. Pengelly (Trans. R. G. S. Corn. vol. vii. p. 118) noticed the occurrence of layers of comminuted, and somewhat rounded, yellowish matter containing rather large rounded slate fragments and ordinary pebbles, on the northern cliffs of the island. Height above high water not given.

3. St. Austell's Bay.

a. A point at which Raised Beach is engraved on the map, at Polkerris, is capped by 8 feet of Head of small angular killas fragments, occasional quartz pebbles were found, being either the relics of a raised beach, or hurled to a height of 30 feet above high-water mark by storm waves from the beach below. This point is joined to the main cliff by a very narrow ridge of rock.

b. Near Polmere the Head rests upon micaceous slates, and in places presents a rudely stratified appearance.

c. Near the Par Inn, a stratified gravel of subangular grit, quartz, slate, and granite stones, and occasional boulders, 4 to 5 feet in thickness, occurs at about 20 feet above high water.

d. On the south side of Spit Point, fine gravel with pebbles of quartz and boulders (one flint pebble found and a fragment of *Cardium, ? in sitû*) 8 feet in thickness, and at base 5 feet above high water, occurs on the low cliffs.

e. Near the above the base of the raised beach is 10 feet above high water, it consists of fine gravel alternating with greyish sand upon large pebbles and unworn blocks of the subjacent rock. The deposit is 10 feet in thickness, the layers appear to dip seaward.

4. Gerran's Bay.

a. On the eastward side of the beach the section consists of—

Brown soil with angular stones	5ft. 0in.
Brown loam with angular fragments of slate and quartz ...	10ft. 0in.
Beds of consolidated black sand and quartz gravel, lying unevenly on the subjacent rock at about five feet above high water	4ft. 6in.

De la Beche (Report, p. 430) mentions the consolidation of portions

[1] Continued from the March Number, p. 110.

of the raised beach in Gerran's Bay by oxide of iron. Near Pendowa the beach is absent, and the Head rests directly on the slates.

b. Mr. Trist (T. R. G. S. Corn. vol. i. p. 111) described the raised beach as a flat stratum of sand and pebbles, sometimes occurring as a black sandstone 2 feet in thickness, sometimes as a conglomerate of sand and pebbles 10 feet thick, resting on limestones and argillaceous schists abounding in manganese, and capped by an argillaceous friable earth.

c. Near Pendover (? Pendowa) beach, Mr. Trist noticed quartz boulders at the Carnes, wholly insulated, and of a different nature from the substratum (*vide* T. R. G. S. Corn. vol. vi. p. 91. Budge.)

d. Dr. Boase (T. R. G. S. Corn. vol. iv. pp. 270, 273) mentions the occurrence of "layers of different substances" in the cliffs to the east of Porthscatho and in Gerran's Bay, the inferior 10 feet being much consolidated. One ferruginous layer resembled pudding-stone. The pebbles diminish upwards into pure sand, reddish brown and friable, in layers 8 or 9 inches thick.

e. (*op. cit.* p. 275.) At Porth, one mile east of St. Anthony, Dr. Boase noticed beds of sand and gravel; Porth farmhouses being built on diluvium of regular beds of sand and pebbles, the latter below; shells, chiefly marine univalves, were found in parallel layers in the sand. The height above high water is not given.

5. Falmouth.

a. Coast-section on the N.E. of Pendennis Castle. Head of angular fragments of slate and quartz with a tolerably regular horizontal lie, 40 to 50 feet in thickness, contains here and there a few pebbles at its base, which is from 5 to 10 feet above high water. Mr. Godwin-Austen mentioned (Q. J. G. S. vol. vii. p. 121) the occurrence of 30 feet of Head on the west of Pendennis Point.

b. Near Cove Battery the Head is of a greyish colour in the upper part, brownish below; a line of larger fragments and a band of loam without stones occur in it.

c. Mr. R. W. Fox (Phil. Mag. and Journ. Science, ser. 3, vol. i. for 1832, p. 471) describes the Falmouth raised beach as a horizontal bed of rolled quartz pebbles, gravel and sand (like the present beach), from 1 to 3 feet in thickness, and generally from 9 to 12 feet above the highest spring tides. The Head upon the old beach is described as earth, stones, and detached pieces of rock. The cliffs are from 30 to 60 feet in height. The old beach does not extend far from the cliff face, it was observed in one place at 8, in another at 20 feet, within it. Between the parishes of Budock and Mawnan the pebbles appeared to be cemented into a conglomerate, in places, by the oxides of iron and manganese.

d. Mr. Godwin-Austen (T. G. S. ser. 2, vol. vi.) describes the old beach and overlying Head at Swanpool as purely marine beds passing up into fluvio-marine and fluviatile accumulations.

e. Between Pennance Point and Maen Porth (Fig. 1), a bed of pebbles, chiefly quartz, with slate boulders, is visible, under Head of angular fragments in loam, at intervals. In one place the beach consists of quartz pebbles in grey and reddish brown sand, with large worn blocks of slaty rocks; 3ft. 6in. thick, and about 4 feet above high water at its base. Rock platforms are noticeable at about the level of spring tide high water.

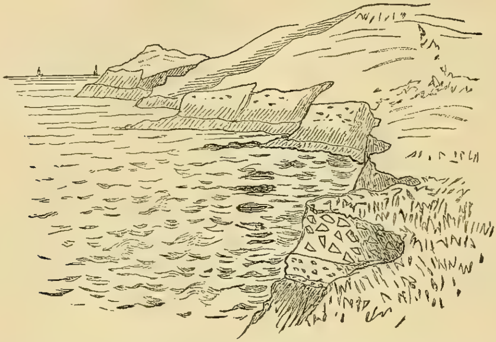

Fig. 1.—The Coast toward Rosemullion Head; showing Rock Platforms and Cliffs composed of Head upon Raised Beach.

6. South of the R. Helford.

a. At Ligwrath, between Nare Point and Porthalla, the Head consists of brown earth with angular stones, pebbles are met with in places at its base, at about 5 feet above high water. Boulders compose the present beach.

b. South of the above, traces of a raised beach consisting of beds of coarse black and brown sand, with grit, slate, igneous rock, and small quartz pebbles, in places 2 to 3 feet thick, and at base about 8 feet above high water, are visible here and there under Head of grey and brown loam with angular stones.

c. De la Beche (Report, p. 431) figures part of a consolidated raised beach forming the roof of a cavern in the slates on which it rests, and supporting a Head of angular fragments, between Porthalla and the Nare Point. He also gives a sketch of the old beach at Nelly's Cove and between Rosemullion Head and Mainporth (*op. cit.* p. 432).

d. The Rev. E. Budge (T. R. G. S. Corn. vol. vi. p. 1) mentions the occurrence of a raised beach, about 5 feet above high water, continuing for some hundreds of yards from Nelly's Cove ($\frac{1}{4}$ mile from Porthalla), and accessible only at low water; he observed traces of the old beach on steep rock ledges now overflowed by the tide. On the north of Nare Point, 8 to 10 feet of angular debris rested on the old beach.

7. Coverack Cove.

a. The low cliffs to the east of Carnsullan are about 15 feet in height, and composed of brown earth with angular and subangular stones and boulders.

b. The Rev. E. Budge (*op. cit.*) describes the cliff-section on the north side of the Cove as—Reddish-coloured marl or rubble upon a thick bed (12 feet) of fine ferruginous sand, consolidated in places, upon large rolled pebbles arranged in regular lines and about 5 feet above high water at their base.

c. The same observer says that the whole of the outer portion of the Lowlands in St. Keverne parish (a flattish tract of 60 acres in extent) is formed of very fine sand (valued for constructing moulds for brass casting), so similar to that overlying the Coverack raised beach that he considered them contemporaneous. At and near the coast-line pebbles were occasionally met with in the sand.

d. Mr. Budge mentions a rampart of large diallage pebbles round a low fortress of sand upon the present beach at Coverack.

e. Dr. Boase (T. R. G. S. Corn. vol. iv. p. 329) mentions the occurrence of diluvium of an ochreous colour consolidated toward its base, and containing small pebbles of quartz, compact felspar, and serpentine, resting on serpentine, near Coverack Quay.

f. De la Beche (Report, p. 129) and Godwin-Austen (Q. J. G. S. vol. vii. p. 121), comment on flints occurring in the Coverack raised beach. Flints also occur in the present beach at Porthbeer Cove, south of Coverack.

8. Gunwalloe. The cliffs are capped in places by a Head of light brown loam with angular stones.

The Lizard District south of a line between Porthbeer Cove and Mullion was not observed by me, nor can I find any descriptions of Pleistocene phenomena on its sea-board. The low cliffs to the south of the Loo bar are capped by about 5 feet of brown loam with angular fragments of quartz, etc., under coarse brownish blown sand.

9. Coast from Loo Pool to Marazion.

a. De la Beche (Report, p. 430) figures part of a raised beach between the Loo Pool and Cove village, stained by black oxide of iron, and containing strings of the same substance, the prevalence of which in the rocks of South Cornwall is pointed out.

b. Mr. Henwood (T. R. G. S. Corn. vol. v. p. 54) noticed patches of granite and slate pebbles, from the size of a nut to a foot in diameter, in Tremearne Cliff. The deposits rested on slates at 14 feet above the present beach, in one spot, and at 30 feet in another, going eastward.

c. (*op. cit.*) "At Wheal Trewavas, where the rock is wholly composed of granite, it is covered by a thick bed of transported fragments of micaceous slate."

d. On the west of Pra Sands, Mr. Henwood (*op. cit.*) noticed a bed of granite, elvan, and slate pebbles, at about 6 feet above the present beach, and covered by "a high bank of rubbish," the debris of the adjacent rocks.

e. Between Cuddan Point and Trevean Cove, the Head consists of dark grey loam with angular (local) fragments.

f. The Perran Sands are bounded by cliffs from 5 to 20 feet high, partly composed of brown loam with angular stones and blocks of greenstone.

g. In a cove west of Perran Sands and south of Perranuthno; in one part—

Brown earth with large and small angular stones	10ft. to 15ft.
upon—large pebbles and subangular fragments of quartz and greenstone	1ft.
upon—brown loam with small angular quartz stones and large angular greenstone boulders.	

g'. In another place—

Soil	2ft. to 3ft.
Brown loam with angular greenstone fragments	6ft. to 7ft.
As above, fragments fewer, and, as a rule, smaller	10ft. to 15ft.
Pebbles, and occasionally subangular fragments, of quartz and greenstone	2ft. (about).

resting unevenly upon greenstone, at from 8 to 12 feet above high water.

h. Toward Marazion the cliffs average 20 feet in height, and are composed of a Head of angular slate, quartz, and greenstone fragments in brown loam.

10. South of Penzance.

a. Mr. Carne (T. R. G. S. Corn. vol. iii. p. 229) observed layers of pebbles and boulders from 3 to 6 feet thick, and 40 feet in length, at the junction of the slate and granite at Mousehole. Mr. Henwood gives the height of the above as a little above high-water mark. (*Ibid.* vol. v. p. 110.)

The following are from Mr. Carne's paper (*op. cit.*).

b. At Carn Silver, boulders and pebbles were found in the end of a cavern, 8 feet wide and 12 feet high, once probably filled with them.

c. In St. Loy Cove, under 30 feet of Head of granitic stones in clay, pebbles and boulders were observed, 4 to 8 feet in thickness, 150 feet in length, and at their base at high-water mark. (Present beach composed of granite boulders.—W.U.)

d. Boulders were also observed at Polwarnon (? Polguaruon) Cove, Lean Scath, Pednvounder Cove (near the Logan rock), and at the Land's End Hole, but their height above the sea is not given.

e. Near Penberth on the east, I noticed a small patch of Head composed of brown loam with angular stones and angular and subangular boulders.

11. Land's End.

a. In Whitesand Bay, near Carn Aire, the Head consists of angular and subangular fragments and boulders of granite in coarse light buff-brown granitic debris (growan), becoming browner and more loamy near the base. The present beach is composed of granite boulders.

b. Between Creagle and Aire Points, Mr. Carne (*op. cit.*) observed 6 feet of boulders and pebbles under 30 feet of clay with granitic fragments. Base of boulder bed at about spring tide high water.

c. On the south of the Nanjulian River (Carne, *op. cit.*) boulders and pebbles occur at 15 feet above high water.

d. On the south of Pol Pry (*op. cit.*), a thin bed of boulders at 20 feet above high water.

e. In an iron vein at Huel Oak Point (*op. cit.*) boulders were found at 8 feet above high water.

12. Pornanvon and Porth Just.

a. In Pornanvon Cove Mr. Carne (*op. cit.*) noticed 2 boulder beds (in a matrix of calcareous sand, granitic gravel and clay), separated by a mass of solid granite. The westernmost bed being 4 chains long, 10 feet thick, and overlain by 60 feet of granitic debris; that on the east was found to be 9 chains long, 20 feet in maximum thickness, and surmounted by 20 to 50 feet of granitic debris. The boulders vary in size from that of a hazel nut to 3 feet in diameter; no large slate boulders were noticed. The base of the deposit is about the level of very high spring tides. At Porth Just Mr. Carne found boulders at 15 feet above high-water mark.

b. Mr. Henwood (T. R. G. S. Corn. vol. v. p. 13) mentioned the occurrence of rounded stones of granite, from the size of a nut to 2 or 3 feet in diameter, with a few slate pebbles, and with granitic sand filling the interstices, at from 15 to 20 feet above high water, at Porth Just and Pornanvon. He says that an adit at Wheal Besans Lode, Little Bounds Mine, was driven for several fathoms through one of these beds, which was found to be from 60 to 70 feet in thickness. (In this estimate the overlying Head was probably included.—W.U.)

c. Miss Carne (T. R. G. S. Corn. vol. vii. p. 371) stated that the adit of a mine south of Kennal Point enters the cliffs under a mass of pebbles and boulders.

13. Cape Cornwall.

a. In the south part of Priest Cove I noticed a few pebbles and subangular stones (one of granite), in olive-brown loam, and, occasionally, greyish sand, under 50 to 60 feet of Head, which presents a stratiform appearance through unequal distribution of fragments, and different tints.

b. In a little cove just north of Cape Cornwall I observed the following section (Fig. 2):—

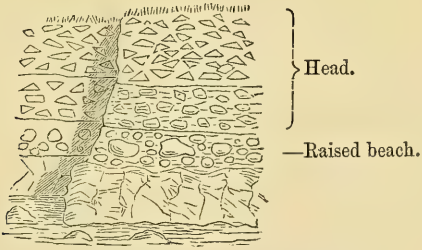

Fig. 2.—Cape Cornwall on the North side.
1 Inch=24 Feet.

Head, brown loam with numerous angular stones, containing larger fragments in the lower 5 feet, with pebbles here and there at and near the base	13ft. 0in.
upon—gravel of pebbles and subangular fragments of slate (altered), quartz, greenstone, a few of flint, and rounded and subangular granite boulders, in coarse brown and black loamy sand	5ft. 0in.

Base of the deposit about 6 feet above high water. Boulders on the present beach. Rock platforms are visible at about high-water mark.

c. In Porthleden Cove the following section was taken:—

Head, brown loam with small angular pieces of quartz, containing small fragments of slate, and, occasionally, granite, 12 feet thick; upon yellowish-brown and brown loam with a few angular fragments; upon well-worn and subangular boulders with a few large pebbles, a few feet above high water.

d. Mr. Godwin-Austen (Q. J. G. S. vol. vii. p. 121) notices the occurrence of granite pebbles, under yellowish clay, with large and small angular stones, and from 5 to 20 feet in thickness, at Creek Tor, in the parish of St. Just, Penrith.

e. On the north of Cape Cornwall, Mr. Carne (T. R. G. S. Corn. vol. iii. p. 229) noticed a bed of slate boulders, 2 feet thick, and a chain in length, on greenstone at 10 feet above high water. The boulders were imbedded in clay and sand with small slate particles.

14. Pendeen Cove (*op. cit.*). Mr. Carne observed 3 feet of small pebbles in sand, made up of comminuted marine shells and pulverized granite, in one place capped by a bed of sand, overlain by 60 feet of Head. The base of the deposit is at about the level of spring-tide high water. The sand is in process of consolidation by iron oxide; it appears to have been blown from the beach into the interstices of the gravel.

(To be continued in our next Number.)

NOTICES OF MEMOIRS.

I.—Geological Notes on Western Africa. By Dr. O. Lenz.[1]

[Communicated by Count Marschall, F.C.G.S.]

1. *The Gabbro of Monrovia.*—Gabbro appears near Monrovia in the form of irregularly fissured, isolated massives, rising above hills covered with the richest tropical vegetation. In its fresh condition it is dark green, distinctly granular, without any traces of schistose or porphyritic texture. Microscopical investigation proves a light-grey plagioclase to be its chief component, together with light-yellow tabular crystals of diallage, and interspersed particles of titanate of iron. The presence of serpentine also is probable, although not ascertained by positive observation.

2. *Polished Rocks in the Beds of Rivers.*—Several of the West-African Rivers, opening into the Atlantic, force the lower portion of their course through a low and long chain of crystalline schists and quartzites, striking N.-S. Violent rapids, cataracts, and cascades, especially in the Congo and Ogowe, are serious obstacles to navigation. The rocks in the bed and on both banks, as far as they come in contact with the waters, are covered with a thin dark-brown varnish-like crust of extremely thin lamellæ of oxyd of iron, whose uppermost surface, continually exposed to the action of water,

[1] [Proceed. Imper. Geol. Instit. Vienna, January, February, and March, 1878.] See also Geol. Mag. Dec. II., Vol. IV. p. 27, and Vol. V. p. 312.

assumes a metallic brightness. The crust is most conspicuous on the gneisses and on the mica-schists with garnets in the Apinshi region. It is absent as well on the portions above the contact of water as on the rocks along the banks where the water flows quietly.

Similar facts have been ascertained on the Rapids of the Nile, on the Cataracts of the Congo (by Captain Tuckey), and on the syenite rocks along the Orinoco (by Alex. von Humboldt). Dr. Darwin observed a black crust, similar in appearance to graphite, on the banks of several Brazilian rivers which open into the Atlantic. Berzelius found this crust to be composed of oxyds of iron and manganese.

The older crystalline rocks of North-west Africa are everywhere overlain by a (probably Diluvial) deposit of intensely yellow, loamy, and highly ferruginous sands, including large blocks of brown hydroxyd of iron. These blocks are aggregated concretions of the size of beans or peas, similar to the pisiform iron-ore of Europe. When such blocks are decomposed, the concretions, bearing distinct marks of having been rolled, are spread over an extensive surface. The rivers carry with them enormous quantities of fine white quartz sand, with flakes of mica, which every year during low water are deposited in enormous sand-banks, rising several mètres above the sea-level. The waters, whirling violently against the rocks, keep in suspension the quartz grains and the concretions of iron-oxyd, and the last material, comminuted by the friction of the hard sand, is deposited on the surface of the rocks in the form of a thin crust.

3. *Geology of the Gold Coast, Guinea.*—The gold here appears in the shape of dust or granules, seldom of the size of a pea. The natives wash it out of the clays and sands in a most primitive way; and they frequently adulterate it, by boring holes into the granules, filling up the cavities with copper or brass, and carefully closing them again. The primary locality of the gold is still unknown.

It is washed everywhere also in the region of the Senegal and Gambia Rivers, as near Cape Palmas, out of a red clay, of probably comparatively recent origin, including layers of rolled ferruginous fragments. Near Accra, close to the sea-shore, there is a coarse-grained, intensely red, and somewhat argillaceous sandstone, with intercalated layers of large rolled fragments of quartz, and without any traces of organic remains. At first view it has a resemblance to some of the Triassic beds of Germany. Further inland are gneisses and granites; and in the Ashanti region and along the river Volta there are fine black amphibolic schists, abounding with garnets, locally of rather large size. Possibly, as in the Ural, these schists may be the primary locality of the gold.

4. *Itabirite (Iron mica-schist) of the Okande Region.*—The Okande region is situated some sixty geographical miles inland, amidst the rapids of the Ogowe. This river breaks its way westward through a chain of schistose rocks, with a main strike N.-S., and with a very steep dip from W. to E. The Itabirite rests on a very thick stratum of white and red quartz, the same which appears, at a lower horizon, intercalated among the mica-schists with garnets of the Apinshi region. In its upper horizons it passes gradually into quartz.

The Okande Itabirite is hard and heavy, its colour is reddish-purple; its texture granular-schistose; its components are quartz, specular oxyd of iron, and magnetic iron. The quartz is conspicuously prevalent, in the form of whitish-grey granules, in coherent parallel layers. The specular iron-ore appears in bright black lamellæ, scattered in the quartz, and frequently bearing a crust of red oxyd of iron. This oxyd appears, likewise, in coherent layers, parallel to those of quartz, and alternating with them. Thus a tranverse fracture offers an alternation of rather broad red and white stripes, interspersed with bright lamellæ of iron-ore. Magnetic iron-oxyd is scattered in minute particles throughout the whole, so that large specimens of this rock cause a marked irritation of the magnetic needle. Atmospheric agents give rise to a thin outward crust of hydroxyd of iron, and make the surface irregularly rough, the quartz offering a greater resistance to these agents than the portions impregnated with oxyd of iron.

The Itabirite of Okande differs from that of Brazil by not including such accessory minerals as gold, talc, chlorite, iron-pyrites, and actinote. Itabirite and analogous rocks, associated with Itacolumnite, were first found in the Schist-formation of Brazil, subsequently in South Carolina, the South-east of France (Département du Var), Portugal (Tras os Montes), and Germany (Soonwald).

The Okande Itabirite is a normal and important constituent of the West-African Schist-formation. It assumes generally the shape of low and ragged cliffs in the river-courses. In the plain of Lope it disappears, almost entirely, beneath beds of Diluvial loam of comparatively recent origin.

5. *Geology of West Africa.*—The islands in Corisco Bay, somewhat north of the Equator, rise about ten mètres above the sea, and are composed of a light-coloured calcareous sandstone, in horizontal strata, overlain with vegetable soil, and extending eastward as far as the mainland at the mouths of the Rivers Muni and Munda. These strata contain many casts of very large, inflated, knotted, and carinated Ammonites, closely allied to *Ammonites inflatus*, a characteristic fossil of the Upper Gault. A well-preserved fragment of this species has been found farther south, in Fish Bay (Benguela). Small, badly preserved Bivalves are of rare occurrence: and carbonized stems of indeterminable plants are frequent. Numerous fissures in every direction are filled up with an uncommonly hard and solid ferruginous sandstone, occasionally also with oxide of iron.

Near Gaboon, white limestones, about two mètres thick, with many veins of calcite, and with local accumulations of Gasteropods, Bivalves, fragments of Crustacea, Echinida, etc., rest on Cretaceous Sandstones. The above-mentioned deposits bear an Eocene *facies*, and are strictly local.

The horizontal Tertiaries of the Loango Coast are overlain by an unstratified deep yellow loam, with nodules of white marl and hollow concretions of hydroxyd of iron, thus nearly resembling Loess. This loam, destitute of organic remains, extends along the coast of Gaboon, on both banks of the Ogowe, even to the outposts of the West-African Schist-formation. Its surface is covered with innumerable granules of pisiform iron-ore, resulting from disaggregation of the concretions of hydroxydated iron. The whole deposit may be compared with what is generally called Diluvium, and may be coeval with the origin of the Ogowe Lakes, on the withdrawal of the waters into their existing beds. Still, a number of larger and smaller lakes exist on both sides of the Ogowe, connected with it by channels, a narrow wall of loam, at most ten to fifteen mètres in height, standing between lake and river. Many blocks of schistose rocks, probably transported by the waters once filling up the whole region from Gaboon to Ncomi (Kamma), are spread over the surface of these natural dykes. The analogy of this loam with the Laterite of East India is conspicuous. At present the Ogowe, in its whole course, down to a few miles above its mouth, carries and deposits only enormous quantities of purest quartz sand, without any trace of loam; while the adjacent loam dykes are completely devoid of arenaceous beds.

The foremost chains of an extensive range of crystalline schists, spreading from the inmost corner of the Gulf of Guinea, Southward to Angola, appear in the Okota region about forty miles inland. The range is composed of many parallel chains, dipping eastward with a steep angle. The lowermost horizon (Okota) has a group of thin-bedded, light-coloured, fine-grained schists, with some mica, locally talcose, and in one place containing a great lenticular intercalation of steatite. Subordinate beds of red and white quartz are not rare, both in the schists, and in the typical granatiferous mica-schists. A ferruginous schist, closely resembling the Itabirite of Brazil, exists along the frontier of the Okande region. Great beds of black siliceous schists extend from the River Okne to the Cataracts of Ndume, at the commencement of the inner plain. Granite, in fine varieties, appears only in large erratic blocks, brought probably from the interior when the Ogowe had a far larger bed.

The *massif* here described appears on the maps as Sierra Complida and Sierra do Crystall, and may be conveniently designated as the West-African Schist Mountains. Globular segregations, including fine crystals of yellow and reddish quartz, and covered on their surface with a peculiar network much resembling honeycomb, are found in both original and derivative situations, in the latter case having probably been transported out of the black siliceous schists mentioned above. The volcanic region of the Cameroon and Rumbi Mountains extends over more than 100 German miles; its highest summits, ascended by MM. Burton and Mann, exceed 13,000 feet. The existence of twenty-eight craters has been ascertained. All the lava-currents have gone southward; and, in this direction, the marginal ashes and slags of the craters are lower and are cut through. Emanations of smoke prove all this region to be still in the condition of a Solfatara. An eruption is said to have taken place between 1830 and 1840; details, however, are wanting. This region is south-westward of the volcanic islands of Fernando Po, Principe

Thomé, and Anobon; and a prolongation of the line connecting these islands reaches St. Helena.

The Clarence Peak on Fernando Po has a height of above 10,000 feet; smoke and fire are said to have been occasionally observed on it. The small island of Anobon seems to have been a single volcano, whose crater has become a lake. Dr. Pechsel-Lösche found on the coast of Loando (3° to 5° S. Latitude) a dark-brown very argillaceous rock of loose oolitic texture, containing Corals and many specimens of *Leda, Mactra, Tellina*, and *Cardium*. Near Landana, well-preserved remains of Fishes (among them the vertebral column and head of a large individual), teeth of Raiæ, palatal teeth, fin-spines, the tooth of a Crocodile, and a coprolite, were found, together with a large Nautilus, some small Gasteropods, and Bivalves. A light-coloured limestone along the coast south of Congo has abundant shells of *Ostrea*.

Very little is known of the Geology of Angola and Benguela. Granites, schists with abundant copper-ores, volcanic rocks, rock-salt, and asphalt are said to occur there. Limestones, in horizontal beds, possibly connected with those along the south coast, and prismatic basalt near Old Calabar, have been observed. The natives oppose any approach of foreigners to the rock-salt deposits.

II.—On the Quaternary Deposits at Westeregeln and Thiede, near Brunswick; in illustration of the Subaerial Origin of Loess. By Dr. A. Nehring.[1]

[Communicated by Count Marschall, F.C.G.S.]

I. *Westeregeln.*—The Quaternary Fauna of this locality is characterized as a "Steppe" fauna by the presence of remains of *Alaktaga Jaculus, Spermophilus Altaïcus, Sp. guttatus; Arctomys Bobak, Lagomys pusillus*, several Eastern-European burrowing *Muridæ*, and Wild Horses, all of them having, apparently, lived in the locality where their remains are now met with. This is shown by the number of both young and adult individuals, and by their good state of preservation. Other species associated with the foregoing offer no objection to the "Steppe" character. *Cheiroptera*, Wolves, Badgers, Hares, Bustards, Ducks, Larks, Finches, Swallows, Frogs, and Toads are not of rare occurrence in the Steppes of East Europe and Asia. *Pelobates fuscus* is said to be frequent around Sarepta and other parts of the Steppes along the lower course of the Volga; and the Pike abounds in the waters of the Steppes. Similar animals have left their remains in the Quaternary deposits under notice. The local Fauna, like that now existing in the South Siberian Steppes, has mixed with it occasional visitors, such as came in summer from Central and South Germany, as Hyænas and Lions, or in winter from northern regions, as Reindeer, Arctic Foxes, and Lemmings. The presence of these last three indicates that the vicinity of what is now Westeregeln was not covered with forests. As to the extinct forms, such as *Elephas primigenius, Rhinoceros*

[1] Imper. Geolog. Institute of Vienna, Report of Meeting, July 31, 1878.

tichorhinus, and *Bos primigenius*, they (with habits similar to those of their living congeners) may have visited the Steppes in those seasons when vegetation had come to its full development there.

II. *Thiede.*—The Quaternary deposits of this locality may be divided into three horizons. The uppermost, about 14ft. thick, begins immediately beneath the vegetable soil, and has the aspect of a Diluvial loam (Loess). From 1 to 9 feet downwards it is more or less dark-coloured by the admixture of carbonaceous substances, and most of its lime has been washed away by percolating waters. Fossil bones are scarce. Remains of a large species of *Bos* have been found at a depth of about 7 or 8 feet; and the remains of Mammoth at 10 feet, close to where the skeleton of a Lion was met with, at a depth of 12 feet, some years ago. At about 12 feet the loam is very calcareous, clear-yellow, fine-grained, and of tubular structure, without any trace of stratification or of plasticity. Not unfrequently it here contains Loess shells, as *Pupa muscorum*, *Succinea oblonga*, and species of *Helix*. This uppermost deposit is so situated that the nearest river (the Ocker) could reach it only when swollen exceptionally high; and wind-action must have been essential to its formation, with occasional local floods after heavy rainfalls.

In the second horizon, from about 14 to 22 feet depth, the material is, for the most part, a highly calcareous Diluvial marl. This includes an abundance of flint pebbles, with both rolled and angular fragments of siliceous schist, Pläner limestone, granite, and quartz. A block of granite weighing about 20lbs. has been found at 16 feet depth,—a subangular fragment of Beyrichia limestone, bearing a distinct impression of *Rhynchonella plicatella* (Kloeden),—an *Ostrea*, possibly from the White Jura north of the Hartz,—and a number of small *Belemnites* (*B. ultimus* or *B. minimus*), much worn, are met with among these fragments. Most probably all these objects have been brought to their present situation, together with the flint implements and fragments of charcoal,[1] by the swollen waters of the River Ocker. The rolled and angular fragments are derived from northern Diluvials, and in part from the Hartz and its outposts. The second horizon may be palæontologically designated as a "Mammoth-deposit," from the frequency of generally well-preserved remains of *Elephas primigenius*. These and the bones of *Rhinoceros tichorhinus* are frequently incrusted or agglutinated with calcareous concretions. Remains of *Hyæna spelæa* and of *Cervus tarandus* are scarcer than those of *Equus caballus* and of a species of *Bos*.

The third horizon, called the "Lemming-deposit," from the prevalence of the remains of this Rodent, reaches from 22 feet depth down to the clefts filled with gypsum, 30 to 35 feet, and at places 40 feet deep. The second and third horizons are connected by palæontological transitions. The prevalent fossil forms are Lemmings; in the upper portion *Myodes lemmus*, and in the lower part less frequently *Myodes torquatus*. *Arvicola gregalis* is rather common. Bones of Reindeer

[1] Rough stone axes under the soil, and flint implements and charcoal in the lower part of the Loess, were found at Thiede by Dr. Nehring, who also met with flint flakes, bits of charcoal, and split bones at Westeregeln.

and Arctic Foxes, both young and adult, are not rare, but much scattered. Remains of *Equus, Arvicola ratticeps, A. amphibia* (or *Myodes Obensis*), *Lagomys* sp., *Lepus* sp., *Spermophilus* sp., and of a species of Bat, seem to exclusively belong to the upper portion. The loam of this horizon contains a notable proportion of sand, and is divided into distinct horizontal strata, two to three centimètres thick, layers with coarse-grained sand generally alternating with beds either containing fine-grained sand, or quite loamy. Here and there large pebbles, up to the weight of 200 grammes, are found, but not so large nor so abundant as in the "Mammoth horizon." The proportion of lime is rather considerable, and calcareous concretions are not of rare occurrence, especially in connexion with the fossil bones.

III. *Conclusions.*—The ossiferous deposits of Thiede are essentially the result of violent currents of flood-waters. During the intervals between two inundations, winds, more frequent in the dry summer months, may have brought a considerable amount of sand and dust over this the exposed region, depositing these substances among the gypsum cliffs of Thiede. The effects of atmospheric currents are chiefly conspicuous in the upper horizon, less distinct in the lowermost, and not at all perceivable in the middle horizon. This assertion is proved, first, by their high level above the present level of the nearest river; secondly, by their petrographical constitution; thirdly, by their organic remains belonging nearly all to land-animals, and mostly to forms proper to Steppes, which are continually subject to subaërial accumulations of sand and dust, such as Von Richthofen has observed on a very large scale in the undrained Steppe-regions of Central Asia. The few traces of water-action may be explained by local inundations, in consequence of occasional heavy rains. If we suppose the "Lemming deposits" of Thiede to belong to the Glacial (and, if we admit two such periods, to the Second Glacial period), the middle and upper horizons at Thiede, as also the whole of the deposits at Westeregeln, should be ranked among those of the Post-glacial period, when Western and Central Europe had taken a more continental form, and certain regions were subjected to a dry Steppe-climate.

REVIEWS.

I.—The Geological Survey of England and Wales.

The Geology of the N.W. Part of Essex, and the N.E. Part of Herts, with Parts of Cambridgeshire and Suffolk. [Explanation of Sheet 47 of the Geological Survey Map of England and Wales.] By W. Whitaker, W. H. Penning, W. H. Dalton, and F. J. Bennett. 8vo. pp. 92. (London, 1878.)

THE Geological Survey is gradually extending its labours over the northern and eastern counties; and there now remains not an English county which has not been partially surveyed, nor one of which some account has not been published "by order of the Lords Commissioners of Her Majesty's Treasury."

Two years ago we called attention (Geol. Mag. April, 1877) to a short memoir on the Geology of the eastern end of Essex, by Mr. Whitaker; we have now the pleasure of announcing the publication of the above-mentioned work, by the same geologist, in conjunction with three colleagues. Most of the field-survey was done (we are told) by Mr. Penning; while Mr. Whitaker himself has performed the duties of editor, in his invariably careful and systematic style.

Much of the country described is comparatively little known to geologists. It lies chiefly in Essex, including the towns of Braintree, Coggeshall, Dunmow, Halstead, Saffron Walden, Harlow, Thaxted, and Witham. In Hertfordshire is included the country around Bishop's Stortford, Buntingford, Hertford, and Ware; in Cambridgshire, that around Linton and Royston; and in Suffolk, that around Haverhill, Long Melford, and Sudbury. The previous observers include the late Rev. W. B. Clarke, John Brown, of Stanway, J. Mitchell, Prof. Prestwich, and Mr. S. V. Wood, Jun.

Geologically the area consists of a great plain of Chalky Boulder-clay, beneath which, in the valleys, are exposed glacial sands and gravels, Tertiary deposits, and Chalk. In the north-western corner of the area a trace of Gault is exposed, and bordering this, near Royston, the Chalk stands out in comparatively bold hills; rising even to 550 feet above the sea-level at Tharfield, where capped by the Boulder-clay.

About half the area beneath the Drift is occupied by Chalk, and nearly half by the London Clay, between which a belt of the Lower London Tertiaries, comprising Reading and Thanet Beds, has been traced, and not without considerable difficulty, owing to the covering of Drift.

A detailed description of the various rocks in the numerous pits and cuttings examined, forms the main feature of this work; the initials of each observer being appended to his statements.

Some disturbances in the Chalk are figured, in one of which cases the beds are tilted at an angle of 60°. Lists of fossils from the various pits are given on the authority of Mr. Etheridge. The account of the Reading Beds is partly re-printed from Mr. Whitaker's Memoir on the London Basin. The description of the Thanet Beds is new, as they were only discovered in this area in 1873, during the progress of the Geological Survey. In the same year Mr. Whitaker also discovered traces of the Red Crag at Sudbury. A short description of these is given, with a list of the organic remains which were in the state of casts or impressions.

Descriptions of the glacial deposits occupy about a third of the work. We should gladly have seen some more definite scheme of classification adopted for these beds, but we are told that "until the work of the Geological Survey in Norfolk and Suffolk is in a more advanced state, it is better for us not to commit ourselves to a scheme of classification, and to be content with the detailed mapping of the beds and their lithological description."

Such being the case, the work cannot possess so much interest for the general reader, but it comprises a valuable store of facts, supplemented in an Appendix with the record of a number of well-sections and borings; and these will be of both practical and scientific value to many living in the district, while they must also aid the theorist in his efforts to account for the formation of the deposits, more especially those belonging to the Glacial period. It will be remembered that in his Memoir on the Geology of the Fenland, Mr. Skertchly spoke with some confidence as to the classification of the Glacial deposits, and of the land-origin of the Chalky Boulder-clay. But we are not treated here to theoretical views. Mr. Penning tells us in regard to the Boulder-clay that it was evidently formed in one continuous sheet, that it rarely presents any signs of stratification, and that its main substance consists of material derived from the rocks at no great distance from the point where it may be observed—facts which coincide with those observed by Mr. Skertchly, and upon which, in part, he based his conclusions.

II.—Monographs published by the Palæontographical Society. 4to. vols. xxxi. and xxxii. 1877–8.

In 1877 Mr. S. V. Wood supplemented the Monograph of the Eocene Bivalve Molluscs, written by the late Mr. F. E. Edwards and himself, with valuable figures and descriptions, chiefly of *Cyrenæ* and *Cyclades*, so important in the history of the Woolwich and Reading beds. He also added an instalment, unfortunately the last that he feels able to contribute, to the Monograph of the Eocene Gasteropods, commenced by the late Mr. Edwards, and continued by himself. Species of the genera *Helix, Cyclostoma, Bulimus, Succinea, Bythinia, Planorbis, Limnæa, Neritina*, and *Nerita*, are the chief subjects of this memoir and its plate, which last has been well and characteristically drawn by Mr. G. B. Sowerby.

Dr. Lycett continued his exhaustive Monograph on the *Trigoniæ* in 1877. Many of the *Costatæ*, and one of the *Byssiferæ*, together with several supplemental species, only lately come to hand, are described and beautifully figured in this part iv. Two specimens from Australia and Lebanon are given in woodcuts for comparison. The lithograph plates, by Lichtenbauer, are beautifully drawn, but give an unnaturally clean and smooth surface to the fossils.

Dr. Traquair's Monograph of the Carboniferous Fishes begins with the *Palæoniscidæ* for part i. (1877). It has an instructive Introduction, both geological and zoological; and treats of *Cosmoptychius striatus* (Ag.); *Elonichthys semistriatus*, Traq.; *E. caudalis*, Traq.; *E. oblongus*, Traq., and *E. striolatus* (Ag.); with seven most teaching and illustrative plates, lithographed from drawings made by Dr. and Mrs. Traquair.

Professor Owen in 1877 enriched palæontology with a concise and masterly account of a great carpal spur or spine of the gigantic *Omosaurus hastiger*, from the Kimmeridge Clay, illustrated with large drawings; and in 1878 he continued his Monograph on the Wealden and Purbeck Reptiles, with descriptions and numerous fine figures of remains of the Crocodilian genera *Goniopholis, Petrosuchus,* and *Suchosaurus.*

Prof. A. Leith Adams supplied in 1877 the first portion of a much-wanted Monograph of the British Fossil Elephants. It consists of descriptions of the dentition and osteology of *Elephas antiquus,* Falconer; with a useful Introduction, and five excellent plates, by Griesbach.

In 1878 Dr. T. Wright gave part viii. of his Monograph of the British Cretaceous Echinodermata, describing and figuring many species of *Epiaster, Micraster, Echinospatagus, Enallaster,* and *Cardiaster.* Several of these are among our most common fossils, and have received so many dubious names and synonyms that both collector and student will now be delighted to have a definite system of nomenclature for use. The many figures in the eight plates are exquisitely, almost too delicately, rendered; they were the last work of the lamented C. R. Bone.

The Introduction, Index, and Title-page of Vol. I. of Dr. Wright's Monograph of British Oolitic Echinoderms, began in 1857, also were issued in 1878.

The completion of Dr. H. Woodward's Monograph of the British Fossil Merostomata, in 1878, is a subject of congratulation to the Society, to the author, and to palæontologists. The comparatively rare occurrence of *Pterygotus, Slimonia, Stylonurus,* and *Eurypterus,* of their Limuloid allies, *Bellinurus, Prestwichia,* and *Neolimulus,* and of their obscure relation the *Cyclus,* all of Upper Palæozoic age, has been counterbalanced by the rather abundant specimens of distinctive fragments and even individuals of some of the species. These precious evidences of extinct life happily attracted the attention of a Carcinologist who had opportunities and the will to study everything that had already been written on these fossils, and to think and work anew among the increasing store of specimens brought under his notice, both in public collections, and by the courtesy and consideration of friends and fellow-workers. How freely some have helped, and how judiciously the author has availed himself of previous useful discoveries and labours, his Monograph clearly shows throughout; but more especially in the treatment and illustrations of the larval *Trilobites,* after Barrande,—the larval *Limulus,* after Packard and Dohrn,—and the anatomy of *Limulus,* at large, after Owen. With this work off his mind, enriched with experience, and lightened with the pleasant thought of well-spent labour, Dr. H. Woodward will soon, we trust, contribute further Monographs on legions of Crustacean Fossils to the Palæontographical Society. The willing concurrence of geologists in helping on the work of the Palæontographical Society, so well shown, as above mentioned, in this Monograph, is equally apparent throughout all the Monographs yet published.

The commencement of Prof. L. C. Miall's Monograph of the Sirenoid and Crossopterygian Ganoids, in 1878, with 32 pages and six plates, opens another pleasant vista to palichthyological students, like that promised by Dr. Traquair's Monograph. The Introduction treats of the real Ganoid Fishes, lucidly and systematically. The recent *Lepidosiren* and *Protopterus* are then described clearly and concisely. The study of the genus *Ceratodus* is taken up at page 18; and, after an illustrated account of the recent form, the fossil teeth from the Trias (one), Rhætic, and Great Oolite (one), (the plates for which hardly do justice to the specimens), are fully described and figured.

Another valuable and longed-for Monograph had its commencement in 1878, namely, that on the Ammonites of the British Lias by Dr. T. Wright. Eight excellent plates of good specimens of the Ammonites, by A. Gawan, are published with this portion of the Monograph; but the text forms part only of the Geological Introduction, describing the succession and characters of the several strata, from the Rhætic upwards. The Ammonites are referred to under the new generic names of *Ægoceras, Arietites,* etc.; and the Lias is described according to its successional zones, as characterized by Ammonitic species, namely, Planorbis-zone, Angulatum-zone, Bucklandi-zone, Turneri-zone, etc. The Continental Lias is throughout carefully brought into comparison with that of Britain, and thus a vast amount of geological information is afforded.

Additional Jurassic Brachiopoda have still turned up, and new observations on species already described have had to be made, so that the persistent energy and cultivated experience of our friend T. Davidson, F.R.S., had abundant matter at hand for the Supplement to his magnificent Monograph of British Brachiopoda; and we have No. 2 of part ii. of vol. iv., with nearly 100 pages and 13 plates, in 1878. An elaborate Table (of nine pages) shows the distribution of Triassic, Liassic, and Oolitic Brachiopoda in Britain; and serves also as an Index to the Supplement, and in some measure to the Monograph also. These plates, like those already given, have been drawn by the accomplished author himself.

"A Preliminary Treatise on the Relation of the Pleistocene Mammalia to those now living in Europe," by Professor W. Boyd Dawkins, was published in 1878, as "Part A" of the Monograph on the Pleistocene Mammalia of Britain, but a considerable part of it had been written in 1872. It is of very great interest, as well to the general reader as to the geologist. Chapter i. gives the definition of the successive ages, from the Historic back to the divisions of the Tertiary Period. Chapter ii. treats of the Wild and Domestic Animals of Great Britain and Ireland in Historic Times, especially the Cattle, and the effects made upon the inhabitants by changes in land, marsh, forest, etc.; a list of these Historic Mammalia is added. Chapter iii. notices the wild and domestic animals of the Continent during Historic Time, climatal changes, and conclusions.—T. R. J.

III.—A Short Introduction to Alpine Geology. By Professor Dr. C. W. Gümbel, etc., etc. With numerous Illustrations. small 8vo. [Kurze Anleitung zu geologischen Beobachtungen in den Alpen; etc., etc.]

THIS very concise, clear, and yet fully expressive account of Alpine geology is really an admirable little geological manual, based on the structure and physical geography of the Alps. It is the geological portion of the "Introduction to Scientific Observation in Alpine Journeys," published by the German and Austrian Alpine Society. How to observe is the first thing taught, both as to rock-materials and the arrangement of strata in general, with their mineral veins, faults, and foldings, and their normal and abnormal successions. The relations of strata to the surface, the origin of springs, also glaciers, caves, etc., are duly noticed or referred to. Alpine structure is then entered upon; and the constituent groups of strata, from the "primitive" or "archæolithic" upwards, with their chief characters and their leading fossils, are excellently well noted and illustrated. The specialities of Alpine rocks, strata, and fossils are next treated of, and shown by sections, etc., in order of stratal sequence from below upwards; so that nothing which a beginner, or even an advanced student, in geology ought to observe or look for, is omitted in this masterly résumé. We know that it is the work of an accomplished geological surveyor and experienced Alpine explorer. T. R. J.

IV.—Handbuch der Palæontologie. By Karl A. Zittel, Professor of Palæontology in the University of Munich, in conjunction with W. Ph. Schimper, Professor at the University of Strassburg, 8vo. vol. i. part ii. pp. 129–307, with 155 wood-engravings. (Munich, 1879.)

THE second part of this excellent Manual of Palæontology will be welcomed by all students of the science, and the long delay in its appearance can be well forgiven when its cause is understood. The first part, dealing with the general principles of Palæontology, with the Foraminifera and with the Radiolaria, was issued in 1876, and there is thus an interval of between two and three years between the dates of publication of the first and second instalments of the work. The obstacle which gave rise to this apparently long delay is to be found in the fossil Sponges. When Prof. Zittel came to grapple with this portion of his subject, he found that it would be necessary either to content himself with a simple compilation of the known palæontological literature dealing with these organisms, or to attack this difficult group of fossils for himself, keeping his mind free from previous prejudices, and starting afresh upon a new basis of investigation. This latter alternative, fortunately for science, was the one finally adopted; and the result is that the chaotic crowd of fossil sponges now stands ranked in regular series, their intimate structure more or less fully understood, and their relations with living forms in many cases completely demonstrated. All zoologists will find cause, therefore, to rejoice that Prof. Zittel should have wisely decided rather to delay his work than to leave the sponges in the unsatisfactory condition in which he found them. From another point of view, it is interesting to note, as evidence of the rapid progress that Palæontology is making, that the author recognizes that the delay which has occurred has already rendered considerable alterations in the first part of the work a matter of necessity. Some of these alterations, such as those necessitated by the appearance of Mr. H. B. Brady's admirable monograph of the Carboniferous and Permian Foraminifera, are so obvious as to call for no comment; but one might doubt the propriety of some of the others, in a work essentially professing to give only the generally accepted and settled facts of the science. One might doubt, for example, if Munier-Chalmas can be considered as having finally proved that *Dactylopora*, *Gyroporella*, and *Acicularia*, are really *Algæ*; or if the researches of Möbius have conclusively demonstrated the mineral nature of *Eozoön*. There are, at any rate, very high authorities who would still be prepared to dispute both of these conclusions.

The general plan of the present instalment of the work is precisely the same as that adopted in the first part. Each group is considered first as regards its general characters; then the classification and taxonomic divisions of the series are dealt with, all the genera being briefly but clearly defined, where their characters are thoroughly understood; and, finally, a short section is devoted to the subjects of geological range and phylogeny. No plan could be devised which would so largely meet the many wants of those who desire to enter upon a really scientific study of fossil organisms, and the manner in which it has been executed, as a rule, deserves the highest praise. The illustrations, without exception wood-engravings, are all good, and many wholly original; and though some may miss the greater delicacy and finish afforded by lithographs, most will appreciate the immense convenience of having the picture of the fossil side by side with its description in the text, and of thus being spared the labour of hunting up the figure in a remote series of plates at the end of the volume.

The groups treated of in Part II. are the Sponges, the Corals, and the Hydrozoa. As regards the first of these, nothing need be said here, as all students of Zoology and Palæontology are already familiar with the beautifully illustrated memoirs on this group, which Professor Zittel has published in the Transactions of the Bavarian Academy of Sciences and the "Neues Jahrbuch für Mineralogie"; and they know therefore how greatly they are indebted to the author. Nor need much be said as regards the Corals; the general treatment of which is in many respects greatly superior to anything to be found in previous manuals of Palæontology, and which has the merit of giving the student the most recent researches upon this subject in a condensed and readily available form. One cannot help recognizing, of course, that Professor Zittel is here not upon ground so thoroughly familiar to him as was the case with the fossil Sponges: and one may feel regret that in the laudable desire to embody the latest information in his work, he should sometimes have so implicitly relied upon writers whose investigations have not yet met with the general approval of their fellow-workers. One may, for example, doubt the propriety of admitting into a systematic work for general students the classification of the Rugose Corals proposed by Dybowski; while the total and absolute abolition of the old division of the *Tabulata* is certainly premature; and it would probably be difficult to bring forward any direct and positive scientific evidence in support of the definite reference of *Syringopora*, *Halysites, Aulopora*, etc., to the *Alcyonaria*, and still less so if that reference places them in the *Tubiporidæ*. At the same time, it is quite unreasonable to expect that any writer of a systematic treatise on Palæontology should, now-a-days, possess an equal, detailed, personal knowledge of *all* the departments of the science, and with this consideration in one's mind, it is impossible to refuse high commendation to the section of his work which Professor Zittel has devoted to the Corals. What has been said above as to the Corals will apply with equal cogency to the portion of the volume which deals with the *Hydrozoa*. The general treatment of the subject is excellent; and even an ill-natured critic would find it difficult to detect other fault than that the author, in accepting the results of the latest investigations, does not, perhaps, sufficiently indicate to the student that these investigations have by no means always received the general endorsement of other high authorities in the same field. For instance, it can hardly be said that *Parkeria* has been *proved* to be really of calcareous composition, and of Hydrozoal affinities. It is probable, at any rate, that well-known names could still be cited in support of an entirely opposite view; and in cases which no one but a specialist can decide, it would seem advisable to indicate that divergences of opinion still exist, and that the question ought to be looked upon by the student as one not yet finally solved. Again, the reference of the Stromatoporoids to the *Hydrocorallinæ*, in close association with *Millepora*, might have been more clearly indicated as a purely provisional arrangement, rendered unavoidable by the absolute necessity of placing extinct groups *somewhere* in the zoological series. No one, probably, would be more ready than the accomplished author to admit that, in spite of what has been done of late years, the entire subject of the structure and affinities of these obscure and difficult fossils has yet to be worked out to a fully satisfactory conclusion; and it would perhaps have been better if this admission had been explicitly made.

Upon these and many other points of a like nature, wide differences of opinion will, and ought, to exist for a long time to come; and it is not altogether unreasonable to think that these differences might with advantage have been more fully recognized in the work before us. No impartial critic, however, can refuse his tribute of admiration in dealing with the work as a whole. It is only as a whole that a treatise of this kind ought to be judged, and from this point of view it would be difficult to award too great praise to the manner in which Professor Zittel has so far carried out his portion of the work. It will be, when completed, incontestably, the best systematic treatise on Palæontology, of its kind, in existence; and no palæontological or zoological student can afford to be without it, if he should wish to enter upon any serious investigation into his subject. From a patriotic point of view, one can only regret that the time has not yet come at which it would be possible to induce any British publisher, with any reasonable expectation of pecuniary profit, to undertake the publication of a similar work. H. A. N.

REPORTS AND PROCEEDINGS.

I.—The International Geological Congress, Paris, 1878.

THE International Congress of Geologists held in Paris during the month of September last seems not to have attracted the amount of attention in England that it deserved; the proceedings of the Congress were by no means devoid of interest, and, indeed, were of some considerable importance, inasmuch as several very valuable papers were read and discussed; attention was also directed to certain lines of geological inquiry now urgently requiring the earnest study and consideration of all geologists.

On the whole, the Conference was very successful, and arrangements were made for holding such gatherings triennially, a great number of the members present pledging themselves to work at certain questions and to present reports embodying the results of their labours at the next Conference, which it was decided should be held at Bologna in October, 1881.

The small amount of notice which the Congress here attracted was probably mainly due to the fact that it took place almost immediately after the meeting of the British Association, and at a time when many other gatherings of a somewhat similar nature were being held; many persons were doubtless surfeited with scientific picnics, and others were, at that time, compelled to start for their real holiday excursions, if they wished to take advantage of the short amount of autumn weather then remaining to them.

The Congress was opened at the palace of the Trocadero on Thursday, August 29, under the Presidency of M. Bardoux, Minister for Public Instruction; there were from 350 to 400 persons present, including amongst their number many of the leading geologists from all parts of Europe and America; at this meeting the Council of Management was elected, with this was incorporated the members of the original committee, appointed at the Philadelphia Exhibition in 1876, viz. Messrs. E. De Baumhuer, J. W. Dawson, James Hall, C. H. Hitchcock, Sterry Hunt, T. H. Huxley, Lesley, J. S. Newberry, R. Pumpelly, W. B. Rogers, and Otto Torell.

The following Members of the Congress, who were all present, with the exception of the English representative, were elected to serve on the Council, viz.:

President:

Prof. M. HÉBERT, Paris.

Vice-Presidents:

For England	Mr. Thos. Davidson, F.R.S., Brighton.
,, Australasia	Prof. Liversidge, Sydney.
,, Belgium...	Prof. De Koninck, Liège.
,, Canada	Dr. Sterry Hunt, F.R.S., Boston.
,, Denmark	Dr. J. Steenstrup, Copenhagen.
,, Spain	Prof. Villanova, Madrid.
,, United States ...	Prof. J. Hall, New York.
,, France	Prof. Daubrée, Ecole des Mines, Paris.

For France	Prof. A. Gaudry, Mus. d'histoire Naturelle, Paris.
,, Hungary	Prof. Szabo, Buda Pesth.
,, Italy	Prof. Capellini, Bologna.
,, Netherlands	M. van Baumhauer, Haarlem.
,, Portugal	M. Ribeiro, Lisbon.
,, Roumania	Prof. Stephanesco, Bucharest.
,, Russia	Prof. De Moeller, St. Petersburg.
,, Sweden and Norway	Dr. Otto Torell, Stockholm.
,, Switzerland	Prof. Favre, Geneva.

Council:

Messrs. Barrande, J., Prague, Bohemia.
Briart, M.A., Pres. of the Geological Society of Brussels.
Chamberlain, Dir. of the Geol. Survey of Wisconsin, U.S.A.
Cook, G. H., Dir. Geol. Survey of New Jersey.
Dewalque, Prof. of Geology, Liège.
Dieulafait, Prof. of Geology, Marseilles.
Dupont, Dir. Natural History Museum, Brussels.
Gosselet, Prof. of Geology, Lille.
Hanks, J., San Francisco.
Hantken, Dir. Geol. Institute, Hungary.
Helland, Delegate from Norway.
Inostranzoff, Prof. of Geology, St. Petersburg.
Jaccard, Prof. of Geology, Neufchatel.
Giordano, Inspector General of Mines, Italy.
Lennier, Dir. of the Museum, Havre.
Loriol, Geneva.
Lory, Prof. of Geology, Grenoble.
Lundgren, Prof., University of Lund.
Malaise, Delegate from the Royal Academy of Sciences, Brussels.
Matheron, Marseilles.
Mayer, Prof., University of Zurich.
Morière, Prof. of Geology, Caen.
Pilar, Prof. of Geology, University of Agram.
Pirona, Delegate from the Institute of Venice.
Renevier, Prof. of Geology, Lausanne.
Saporta (Comte de), Corr. Member of the Institute of France.
Sella, late Minister for Public Works, Italy.
Selwyn, A., F.R.S., Dir. of the Geological Survey of Canada.
Sirodot, Prof. of Geology, Rennes.
Winkler, Dr. T. C., Haarlem.

Secretaries—Messrs. Brocchi, Delaire, Sauvage, and Vélain.

Treasurer—A. Bioche.

General Secretary—A. Jannettaz.

The propositions specially laid down, and previously published in the programme, for the consideration of the Congress, were the following:—

1. The unification of geological signs (*i.e.* colours and conventional signs).
2. The discussion of various questions relative to the limits and characters of certain formations.
3. The representation of faults and veins.
4. The respective values of the fauna and flora in defining beds.
5. On the value of the mineral composition and texture of rocks in determining their origin and age.

Some thirty and odd papers bearing more or less closely upon the above propositions were read and discussed.

At the last meeting international commissions were appointed to consider certain propositions, and to report upon them at the meeting to be held at Bologna in 1881. Two of them are matters of the utmost importance to geologists, and if they be well and honestly worked out, the results should prove of the greatest use and benefit to Science.

1. An International Committee for the Unification of Geological Signs, composed as follows:—

For England	Prof. T. McKenny Hughes, Cambridge.
,, Australasia	Prof. Liversidge, University of Sydney.
,, Belgium...	M. Dupont, Dir. of Nat. Hist. Mus., Brussels.
,, Canada	Mr. Selwyn, F.R.S., Dir. Geol. Survey, Canada.
,, Spain and Portugal	M. Ribeiro, Dir. of the Geol. Survey of Portugal.
,, United States ...	Mr. Lesley, Dir. Geol. Survey of Pennsylvania.
,, France	M. De Chancourtois, Ecole des Mines, Paris.
,, Hungary	M. De Hantken, Dir. Geol. Inst. Hungary.
,, Italy	M. Giordana, Rome.
,, Russia	M. De Moeller, University of St. Petersburg.
,, Scandinavia	M. Otto Torell, Dir. Geol. Survey of Sweden.
,, Switzerland	Prof. Renevier, Lausanne.

2. The Committee for the Unification of Geological Nomenclature is as follows:—

For England	Prof. T. McKenny Hughes, Cambridge.
,, Australasia	Prof. Liversidge, Sydney.
,, Canada	Dr. Sterry Hunt, Boston, U.S.
,, Spain and Portugal	Prof. Villanova, Madrid.
,, United States ...	Prof. J. Hall, New Jersey.
,, France	M. Hébert, Paris.
,, Hungary	Prof. Szabo, Buda Pesth.
,, Italy	Prof. Capellini, Bologna.
,, Roumania	Prof. Stephanesco, Bucharest.
,, Russia	Prof. Inostranzoff, St. Petersburg.
,, Scandinavia	Prof. Lundgren, Lund.
,, Switzerland	Prof. A. Favre, Geneva.

The members of these international commissions are charged with the formation of local committees in their respective countries; each committee is to have the power to choose its own president and secretaries.

The reports of the committees are to be forwarded to the central committee at Bologna by January 1st, 1881, which is charged with the duty of printing and distributing the same before the opening of the Congress in the October of that year.

The French Government has undertaken to print the Proceedings and Papers of the first session of the Geological and other Congresses (some 30 in number) held during the Paris Exhibition.

The Geological Society of France threw open its rooms to the Members of the Congress, not only during the actual week of the meeting, but for some time both before and after. Arrangements were made also for several very interesting geological excursions, which were well attended, and went off very pleasantly and successfully.

A very notable and useful feature in the arrangements for the Congress was the publication and gratuitous distribution of a very full and valuable "Guide" to the Geological and Mineralogical Collections at the Exhibition, and to the various public and private collections in Paris; this book, consisting of about 160 pages, described the principal features of the different collections—the plan that accompanies it indicated the positions of the geological exhibits in the building; without this "Guide" many of the collections scattered over the vast building on the Champs de Mars might easily have been overlooked even by the most careful. The book is divided into three parts,—the first part treats of the geological collections according to their range in time, or as it is headed—"Stratigraphical Geology;" the second part treats of the collections according to the countries from which they were sent; whilst the third division of the book is devoted to the mineral collections and mineralogical apparatus.

The Organizing Committee for the next meeting at Bologna in 1881 is composed as follows:

Patron—His Majesty the King of Italy.

Honorary President—M. Sella, President of the Academy, Rome.

Messrs. Capellini, The Museum, Bologna.
Gastaldi, Prof. of Geology, Turin.
Taramelli, Prof. of Geology, Pavia.
Omboni, Prof. of Geology, Padua.
Meneghini, Prof. of Geology, Pisa.
Ponzi, Prof. of Geology, Rome.
Giordana, Chief Engineer of Mines, Rome.
Guiscardi, Prof. of Geology, Naples.
Gemmellaro, Prof. of Geology, Palermo.
De Pirona, Prof. of Geology, Venice.

The Italian Government and the Municipality of Bologna have offered their assistance in making arrangements for the reception and convenience of the members of the Congress during their stay in Bologna. A. L.

II. Geological Society of London.—I.—Annual General Meeting. February 21st, 1879.

Henry Clifton Sorby, Esq., F.R.S., President, in the Chair.

The Reports of the Council and of the Library and Museum Committees for the year 1878 were read and ordered to be printed.

The Wollaston Gold Medal was awarded by the Council to Prof. Bernard Studer, F.M.G.S., "the father of Swiss Geology."

The Murchison Bronze Medal to Prof. M'Coy, of Melbourne University.

The Lyell Gold Medal was awarded to Prof. E. Hébert, of Paris, for his investigations of the Cretaceous formation, etc.

The Bigsby Gold Medal to Prof. E. D. Cope, of Philadelphia.

The "Wollaston Donation Fund" was awarded to Mr. Samuel Allport, F.G.S., of Birmingham, in aid of his researches in the Microscopical Structure of Rocks.

The "Murchison Geological Fund" was awarded to Mr. J. W. Kirkby, of Leven, Fife, N.B., in aid of his researches in the faunas of the Magnesian Limestone and the Carboniferous strata.

The "Lyell Fund" was awarded in equal moieties to Prof. H. Alleyne Nicholson, M.D., F.G.S., of St. Andrews, for his various and important researches in Palæozoic Palæontology: and to Dr. H. Woodward, F.R.S., in recognition of his work on Fossil Crustacea, etc.

The President then proceeded to read his Anniversary Address, which was devoted to the examination of the structure of limestones, and the means presented, especially by optical investigation, for determining the origin of their constituent particles.

II.—February 26, 1879.—Henry Clifton Sorby, Esq., F.R.S., President, in the Chair. — The following communications were read:—

1. A copy of a Letter from the late Acting Governor of the Falkland Islands, relating to the overflow of a peat-bog near Port Stanley, in East Falkland. Communicated by H.M. Secretary of State for the Colonies.

2. "Note on *Poikilopleuron Bucklandi*, of Eudes Deslongchamps (père), identifying it with *Megalosaurus Bucklandi*." By J. W. Hulke, Esq., F.R.S., F.G.S.

The author stated that the genus *Poikilopleuron* was founded by Deslongchamps, after much hesitation, to receive some Megalosauroid fossils found in a quarry near Caen; and that he gave them the specific name "*Bucklandi*" with the view of facilitating the union of the two genera, should this be found necessary. The author reviewed the evidence on which the genus *Poikilopleuron* rests, indicating the close resemblance of the remains to those of *Megalosaurus*, and showing that a medullary cavity exists in the vertebræ of the latter, thus getting rid of the most important difference between the two supposed genera. The author's conclusion was that *Poikilopleuron* and *Megalosaurus Bucklandi* were identical.

2. "Note on a Femur and a Humerus of a small Mammal from the Stonesfield Slate." By H. G. Seeley, Esq., F.L.S., F.G.S., Professor of Geography in King's College, London.

The author described a small femur and humerus preserved in slabs of Stonesfield Slate in the collection of the British Museum, to which they were presented many years ago by Mr. Pease Pratt. The bones nearly correspond in size, and, in the absence of evidence to the contrary, the author preferred to regard them as possibly belonging to the same animal. From their characters the author was inclined to associate them with the jaw known as *Phascolotherium*, and to believe that they represented a special, probably insectivorous, monotreme type, with indications of marsupial tendencies, such as, on the hypothesis of evolution, might well be expected to occur early in the development of the Mammalia.

3. "A Review of the British Carboniferous Fenestellidæ." By G. W. Shrubsole, Esq., F.G.S.

In this paper the author gave the results of his investigation of the Fenestellidæ from the upper beds of the Carboniferous Limestone on Halkin Mountain, in Flintshire. He stated that the described Carboniferous species of *Fenestella* now number 24, of which he has been able to examine 19, and finds that they have been needlessly multiplied, owing especially to the neglect on the part of describers to allow for difference in the structure at various stages of growth and in different parts of the polyzoarium. His investigations led him to refer the forms known to him to only 5 species, namely, *Fenestella plebeia*, M'Coy, *F. crassa*, M'Coy, *F. polyporata*, Phill., *F. nodulosa*, Phill., and *F. membranacea*, Phill.

CORRESPONDENCE.

THE CALDER VALLEY.

Sir,—Will you permit me to thank my friend Mr. Dakyns for drawing the attention of your readers to two or three particulars having reference to the physical forces which have caused the configuration of the Valley of the Calder. He is puzzled by the statement that heather and peat are found above sandstones, and that the heather does not grow on limestones or shale or clay, further observing that he has generally noticed the peat underlain by a bed of yellowish clay, very similar to the underclay of a coal-seam. Of course, Mr. Dakyns is correct. I do not suppose any one would expect to find any plants, except lichens, growing on a bare mass of rock. The disintegration of the sandstone by atmospherical agencies, and the decay of organic matter, will tend to form a soil in which the heather can take root, and which may eventually assume the appearance indicated by Mr. Dakyns. Taking the facts, however, in the broad sense which I intended in the paper, we do find that the heather grows only on the moorlands constituted of sand or gritstone. I could quote numerous instances where a sharp line can be drawn between the sandstones and shales which form the surface stratum, by the occurrence or otherwise of heather growing above it, and I am sure it is unnecessary to remark that heather is not a characteristic plant on limestones.

I did not intend that any geological beginner should imagine that the *present faces* of the corresponding escarpments of the Yorkshire and Lancashire grits were ever in contact, and I venture to think that the purport of the paper will show that a constant change of form is in progress, and that the rock escarpments are always subject to the disintegrating action of water or frost. There can be little doubt, also, that the original faces of the rocks would be borne further and further from the centre of operations at the time that the elevation took place, and that some part of the distance by which the opposing escarpments are separated at present is due to this cause.

I am afraid my reasons for considering that the drift or gravels in the Valley of the Calder have been transported to their present position during a period of submergence would occupy more space than could be devoted to a letter, and with your kind permission I will defer stating them to some future time.

Chevinedge, Halifax, *February 19th*, 1879. James W. Davis.

THE DEVONIAN QUESTION.

Sir,—It is with much pleasure I have read Mr. Champernowne's communication on "The Devonian Question" (Geol. Magazine, March, p. 125). Knowing how sedulously he has been studying the Devonshire rocks for some years past, I regard his opinion as of great value; and, therefore, when I find it to be confirmatory of the views I ventured to suggest, I am strengthened in the belief that they are (to use Mr. Champernowne's own words) "in the main legitimate deductions from the facts, and not mere theory." The evidence which Mr. Champernowne has adduced of the Silurian affinities of the Foreland Sandstones is of much importance at the present time—because it bears by a reflex process of reasoning on the question of the age of the supposed representative beds—those of the Glengarriff and Dingle series in the South of Ireland; a question which is still *sub judice.*

As regards the suggested unconformity at the base of the Pickwell Down Sandstone, it is in no way necessary to my argument; and I am quite content to abandon the idea on the statements of two of my friendly critics. But I would suggest to Mr. Champernowne, in reference to the difficulty he feels regarding the S. Wales district (Professor Geikie's "Welsh Lake"), whether there may not be a break between the "Pebbly beds and Conglomerate" and the "Cornstone" series, etc., of Monmouthshire ("Siluria," 4th edit. p. 245), the former of which I cannot but regard as the equivalent of the Pickwell Down Sandstone.

As Mr. Champernowne has anticipated my reply to Mr. Hall and Mr. Ussher (though probably the latter has by this time discovered that he had entirely misunderstood the purport of my paper), it is scarcely necessary that I should add anything to his statements. I will, therefore, only ask him in conclusion to weigh the evidence I have adduced in the same number of the Geological Magazine, p. 129, for believing that the Red Sandstone and Conglomerate of the South of Ireland, which passes up into Griffith's "Yellow Sandstone," is really the representative of the true "Old Red Sandstone" of other districts, and not merely the base of the Carboniferous Series. Edward Hull.

Dublin, 10th *March*, 1879.

MISCELLANEOUS.

Fossils from the Diamond Fields, South Africa.—Mr. George J. Lee, of Kimberly, Griqua-land West, has forwarded, through His Excellency Colonel Lanyon, the Governor of the Colony, to Sir Joseph D. Hooker, C.B., for presentation to the British Museum, part of a carbonized[1] branch of a Coniferous tree (found 195 feet below the surface in Claim 196); a fragment of a fossil fish (*Palæoniscus*) of Triassic age; and four casts of portions of the vertebral columns and ribs, and a foot of small Dicynodont reptiles, preserved as hollow moulds, in finely laminated and friable shale. Also numerous pyritised bodies, possibly replacing some organism. The Reptilian remains have been submitted to Prof. Owen, C.B., who will notice them more fully hereafter. The fossil wood will be examined by Mr. W. Carruthers, F.R.S.

[1] Resembling charcoal in its mineral condition.

THE

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NEW SERIES. DECADE II. VOL. VI.

No. V.—MAY, 1879.

ORIGINAL ARTICLES.

I.—On the Discovery of a Species of Iguanodon in the Kimmeridge Clay near Oxford; and a Notice of a very Fossiliferous Band of the Shotover Sands.

By Prof. Prestwich, M.A., F.R.S., V.P.G.S., etc.

An interesting discovery has just been made in this district. A short time since some workmen from Cumnor brought to the Museum a basketful of bones which they said they had found in digging the clay at the brick works, now in course of large extension, at Cumnor Hurst, three miles west of Oxford. On cleaning the specimens, the characteristic vertebræ and teeth of *Iguanodon* were recognized. A large number of the vertebræ are entire, but the jaw is in fragments, with many teeth, however, in position. The skull is wanting, except a small fragment. One of the feet, with the claws, is almost complete. The larger bones are almost all broken, but we hope to be able to reunite many of the fragments, as there is reason to believe that the skeleton was entire or nearly so. The smaller bones and the extremities of the larger bones are in a beautiful state of preservation. It is a smaller animal than the Wealden *Iguanodon Mantelli*, but whether owing to age or difference of species remains to be determined. It seems to me to indicate a different species, with smaller and more delicately-formed bones.[1]

On visiting the place, I found that the specimens had been met with in driving a tramway into the side of the hill, where new pits are being opened out. Consequently a cutting only a few feet wide was made, and which, at the spot where the bones were found, was about seven feet deep. The clay was bare at the top, though a little disturbed. The bones were found at a depth of about four feet, in a thin seam, two or three inches thick, of yellow sandy clay, and they had extended part of the way across the cutting. A further portion of the skeleton may therefore remain in the undisturbed beds on one side. There is reason to believe that some portion of the bones were carted away, but I hope these may yet be traced; while, with the obliging assistance of the manager of the works, a watch will be kept on the clay at the sides when it has to be removed.

[1] The *Scelidosaurus Harrisoni*, Owen, from the Lias of Lyme Regis, is closely allied to *Iguanodon*, but is much smaller; so also is the *Acanthopholis horridus*, Huxley, from the Grey Chalk of Dover.

The thin sandy seam, being very conspicuous in the dark clay, can be traced on the side of the cutting (which deepens gradually as it proceeds further into the side of the hill) in a position nearly horizontal but slightly waved, until it is lost under about ten feet of the clay. In the part over the bone seam, where the men are now digging, I found a few perfectly characteristic shells of the Kimmeridge Clay, such as *Exogyra virgula, Cardium striatulum, Thracia depressa, Ammonites biplex,* together with *Lima pectiniformis,* and *Serpulæ.* A pit a few yards further on showed an additional six feet of clay, overlaid by the ferruginous sands, the equivalent of the Shotover beds, but without any organic remains.

There can be no doubt, therefore, of the position of this remarkable fossil, which shows that the *Iguanodon,* or some closely allied Dinosaur, was not confined to the Lower Cretaceous and Wealden beds, but existed during the period of the Kimmeridge Clay. Nothing else besides a few fragments of drifted wood indicates the neighbourhood of dry land, unless the thinning off of this formation to less than 100 feet in this district be due to the approach to an old shore-line, and not to the removal of higher beds by denudation. With the later setting in of the Shotover sands, with their shells (*Unio, Paludina, Cyrena*) and plants (ferns and numerous remains of reeds and grasses), we pass into well-marked land and freshwater conditions, but at Shotover the sands of the Portland series intervene between the two. It is probable, however, that the same old land surface, indicated by the latter, was, during the Kimmeridge period, only a short distance further off, and that its gradual rise finally displaced the Portland sea in the Oxford area. We might therefore have had continuity of land conditions and consequently of the land fauna from the Kimmeridge to the Lower Greensand period.

I may take this opportunity to mention, for the information of any geologists who may be visiting the classical district of Shotover Hill, that the above-named freshwater mollusca, which are so rare in the old pits above Headington at the west end of the hill, occur abundantly at the east end of the hill near Wheatley. About three years since, a pit was opened for the extraction of yellow ochre and iron ore, some 200 or 300 yards west of Wheatley windmill. It was twelve feet deep, and consisted of beds of rubbly iron sandstone, impure limonite, and yellow ochre. At the depth of about seven or eight feet a thin seam of iron sandstone, at the base of the main bed, six to eight inches thick, was literally full of casts and impressions of these shells—chiefly *Cyrena* and *Paludina*; while another thin band was covered with ripple markings and matted with indeterminable plant impressions. Soon afterwards, however, owing to the fall in the value of iron and the other products, the pit was, unfortunately for geologists, closed, and has since been filled in; but there still remains on the opposite side of the lane an old pit in which the same shelly seam may be found, though not so well developed and continuous. The only addition to the fauna of these Shotover Sands made since the publication of Prof. Phillips' "Geology of the Neighbourhood of Oxford," etc., is by Prof. Rupert Jones, F.R.S., who found in a small slab of the Ironstone a few bivalved Entomostraca, which he refers to a species of *Candona*, and four species of *Cypridea*. They are described in the Geol. Mag., 1878, Decade II. Vol. V. pp. 100 and 277. They are Wealden species.

P.S.—Since writing the above, I have taken a few of the remains up to the British Museum, where they have been submitted to examination and comparison by Mr. William Davies, F.G.S., who has kindly pointed out to me that there are, among these, portions of jaws with successional teeth; dorsal, sacral, and caudal vertebræ, scapula, humeri, pelvic bones, portions of femora, fibulæ, astragalus, phalanges; and other bones not yet determined. Mr. Davies has no doubt that the remains are those of a young Iguanodon, the epiphyses of the limb-bones being unanchylosed.—J.P.

II.—On *Trigonia Elisæ*—Cornet and Briart.[1]

By Dr. Lycett.

The Whetstones (Meule) of Bracquegnies, Belgium, are upon the same geological horizon (zone of *Ammonites inflatus*, Sow.) and are identical lithologically with the well-known Whetstones of Blackdown; like to the latter deposits they are characterized by the prevalence of *Trigoniæ* which are allied to, but are for the most part not strictly identical with the species of Devonshire. The *Trigonia Elisæ*, Cornet and Briart, herewith figured, is allied to and equals in

Trigonia Elisæ, Cornet and Briart.—Greensand, Bracquegnies, Belgium.

1

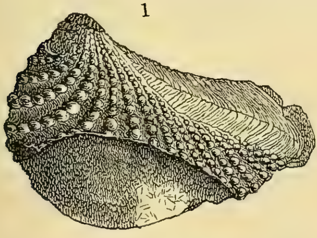


Fig. 1. Side view.

2

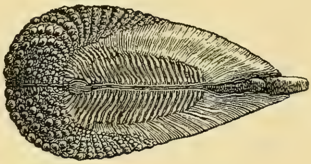


Fig. 2. Umbonal view.

abundance the well-known *T. aliformis*, Park., of Blackdown, and is the Belgian representative of that group of *Trigoniæ*. Like the Devon species it is remarkable for the great length of the hinge-border, and the produced, attenuated posterior side, with its short siphonal border; but is without the anteal inflation of the valves and the peculiarities of the costæ which distinguish *T. aliformis*, Park. For the latter, see Monograph of British Fossil Trigoniæ, Palæontographical Society, 1877, pl. 28, figs. 5, 5*a*.

Another abundant *Trigonia* at Bracquegnies is the *T. dædalea* of Cornet and Briart. This differs from the well-known common

[1] Cornet and Briart, Description de la Meule de Bracquegnies, Mémoires Couronnes et Mem. des savant Etrangers, Acad. Royal de Belgique, t. xxxiv. 1868.

Blackdown form bearing the same name, but is identical with a large variety of that species which has occurred rarely in the Whetstones of Little Haldon, figured as *T. dædalea*, var. *confusa*, in the Monograph above quoted, pl. 23, fig. 1. Fine examples of the latter form are exhibited upon the tablets of the British Museum as *T. dædalea*, Park. Other *Trigoniæ* occur in the Belgian beds, but the two here alluded to are the most abundant and characteristic species.

III.—Notes on Palæozoic Crustacea.

Eurypterus Scouleri, Hibbert.

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

(PLATE V.)

AMONG the many relics of Palæozoic life-forms which the Carboniferous formation has yielded to the palæontologist, none is more remarkable than "Scouler's Eidothea," or the *Eurypterus Scouleri* of Hibbert.

This fossil Crustacean is of itself sufficiently bizarre in aspect to arrest the notice of even the most casual observer, whilst its geological history is equally curious.

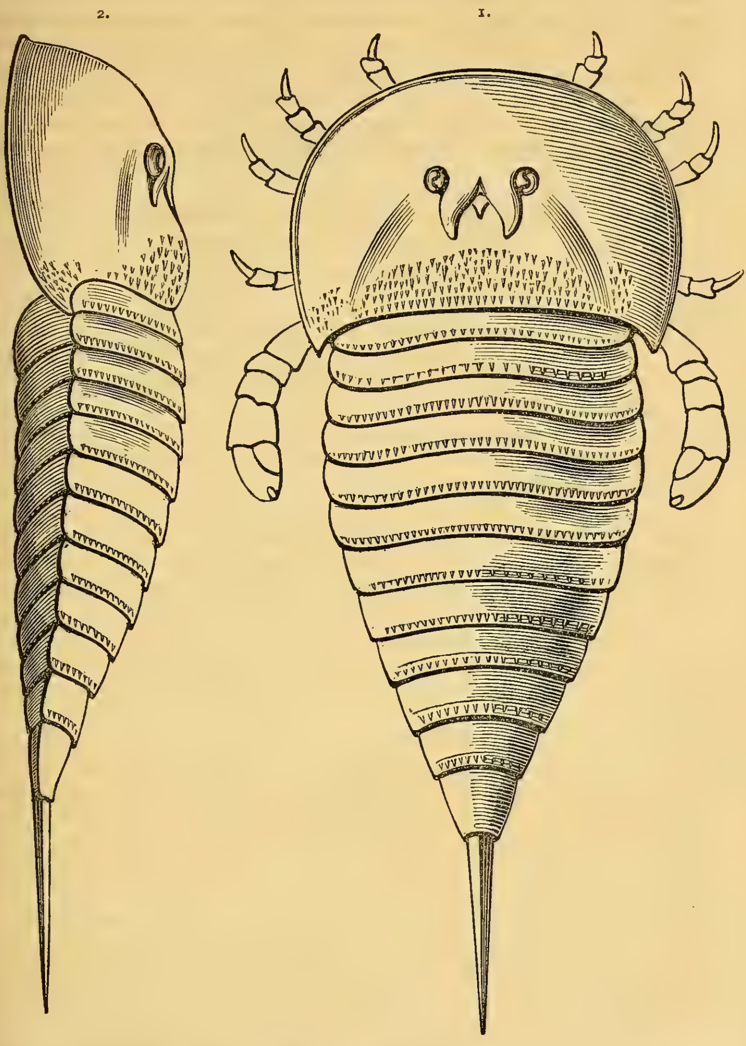
The Carboniferous epoch, however, is rich in interest; for it is, above all others, that, at which the ideal boundary-line for the Biologist should be drawn, which marks more clearly than any other the incoming of the recent, and the outgoing of the extinct faunas of our globe.

As we scan the record of these old Carboniferous rocks, so rich in organic remains, we seem to stand on some lofty beacon-hill, whence we can cast our glance upwards and downwards along the stream of Time.

Beneath our feet lie buried the last representatives of those aboriginal races, now quite extinct, the Trilobita and the Eurypterida, whose ancient hosts peopled the seas of the Devonian and Silurian ages, and reached far away into the Cambrian epoch. Beside them lie the earliest representatives known of our modern Decapoda, Stomapoda, and Isopoda, then but few and feeble, but now the dominant races of the Crustacean class.

Eurypterus Scouleri is the last representative of the extinct Eurypterida—probably the only order in the class Crustacea which have really died out. For the modification necessary to convert the extinct order Trilobita into its modern representative order, the Isopoda, seems a far lesser metamorphosis of organs than that needed to transform the aquatic *branchiated* order Eurypterida into the terrestrial *pulmonated* Arachnida (Scorpionidæ); yet not only these, but many other similar modifications, resulting in the extinction of the older type and the extension of the newer form, have doubtless taken place since the Carboniferous epoch.

This last species of *Eurypterus*, of which our plate affords an attempted restoration, has been fully described, so far as the materials existing admitted, in a Monograph on the Merostomata, by the writer. (See Pal. Soc. Mons. 1866-78. Part IV. 1872, pp. 133-139.)



Eurypterus Scouleri, Hibbert, 1836.
(Restored.)

Lower Carboniferous Freshwater Limestone.

KIRKTON, NEAR BATHGATE, WEST LOTHIAN.

Fig. 1. Dorsal view. Fig. 2. Side view.

Fig. 3. Eurypterus Scouleri, Hibbert, 1836.
(*Under side restored.*)

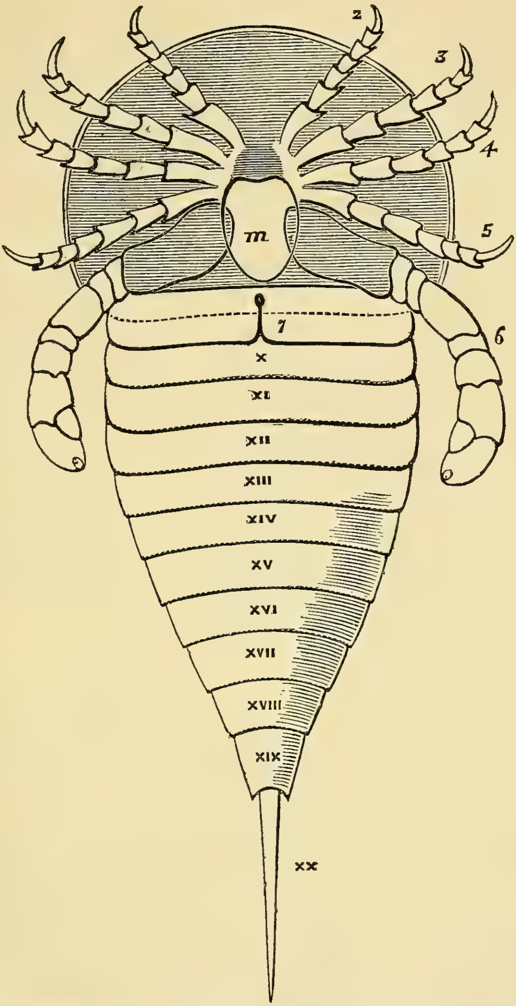


Fig. 2. Antennæ. 3. Mandibles. 4. 1st Maxillæ. 5. 2nd Maxillæ. 6. Maxillipeds; serving in this order as the chief locomotory organs. *m.* The metastoma or post-oral plate. 7. The thoracic plate or operculum, covering the branchiæ. Figs. i.–vii. The head-shield.[1] Figs. viii. and ix. are concealed by the operculum. Figs. x.–xix. Thoracico-abdominal somites destitute of any appendages. Fig. xx. The telson; or tail-spine. For dorsal view, see Pl. V.

[1] As the antennules in the Eurypterida are, theoretically, considered to be aborted, the head-shield would be really composed of the 7 cephalic and the 1st thoracic somites; but the Roman numerals only indicate the number of somites coalesced in the head-shield which are actually represented by *paired* appendages, reckoning the optic segment as the first, and the thoracic plate or operculum as the seventh.

It was pointed out at that time (1872) that this singular species "presents many anomalies and considerable divergence from the type-form of *Eurypterus remipes,*" De Kay, from the U. Silurian of New York.

"In the curious form of the eyes, elevated above the carapace, upon a round base or peduncle, and in the singular bifurcating median ridges, or crests between the eyes, we are reminded of *Stylonurus Scoticus;* but the rounded, almost hemispherical head-shield, finds its analogue alone in the carapace of the modern *Limulus.* In point of size, *E. Scouleri* claims a place among the largest of the Merostomata." (op. cit. p. 138.)

Our restoration is based upon an acquaintance with two separate heads—one of which is almost completely perfect, and has the two most anterior segments attached to it; and a body, made up of the eight hindmost body-rings, all duly united and showing both upper and lower surface entire, and preserved in the round. Of the mouth organs we only know the basal joints imperfectly, from a specimen of a head in Mr. James Powrie's collection, which we were permitted to develope upon the under side; but from the entire absence of appendages to the body-segments, we are justified in concluding that its mouth organs also subserved the office of locomotory appendages, as in the rest of this singular order.

From the form of its body there can be little doubt that its habit was aquatic and not terrestrial, for we have detected the thoracic plate which must have covered the branchiæ, and there is no evidence of trachæal openings in the body-segments. But, on the other hand, there seems good geological evidence for concluding that *Eurypterus Scouleri* was an inhabitant of *freshwater.*

The following description of the locality whence it was derived is most suggestive:—

The specimens are from a quarry at Kirkton, near Bathgate, West Lothian, which, it would appear, is not in the Coal-measures proper, but in the Carboniferous Limestone. The bed is described in a Memoir by Dr. Hibbert, upon certain freshwater limestones (Trans. Roy. Soc. Edinb., vol. xiii. 1836).

"A mile or two to the east of Bathgate, at Kirkton, we find that a very considerable outbreak of Greenstone has occurred. Close to it on the west appears the limestone of Kirkton. By this contiguity, we are assured that the limestone must have been elaborated within the immediate sphere and influence of an extensive volcanic eruption. The consequence has been that one of the most unique formations of which Great Britain can boast has been formed, indicative of *thermal waters,* belonging to the Carboniferous epoch.

"A decidedly freshwater formation is thus exposed, which is characterized by the absence of all marine shells, corallines, etc., and the presence of the well-known vegetable-remains of the Coal formation.

"But the remarkable circumstance in this limestone is its mineralogical character, indicative of the very powerful chemical action under which it was elaborated. This chemical action appears to have been so energetic, as to have caused such miscellaneous earthy matters as are found to enter into the composition of an impure limestone, like that of Kirkton, to separate into laminæ, and to assume a sort of striped disposition (*rubané* as it is also named), resembling what I have occasionally noticed in Auvergne, where Tertiary strata have come into contact with volcanic rocks. The strata, for instance, of Kirkton quarry, are composed of distinct and alternating thin laminæ, some of them being of remarkable tenuity, variously consisting either of pure calcareous matter, of translucent silex, resembling common flint, or of a mixed argillaceous substance, which approaches to the character of porcellanite, or of ferruginous, or even of bituminous layers, originating probably from vegetable matter.

"Upon one of these very thin aluminous folia, which I have compared to porcellanite, I observed the impression of a Fern, apparently of a *Pecopteris*, which was delineated upon it like a painting upon porcelain."

This fern, which has been named *Sphenopteris affinis* by Lindley, is associated with stems, leaves, and fruits of *Lepidodendron*, *Calamites*, and many other plants. Entomostraca are also abundant.

Our restoration of the appendages made (in 1872) after the American species, *E. remipes*, figured by Prof. James Hall, may possibly need modification when more materials for their better reconstruction are available. Meantime we venture to draw the attention of Scottish geologists to this very interesting and classical locality in the hope that new light may be afforded thereby as to the nature and affinities of this singular Freshwater Crustacean.

IV.—On Professor Dana's Classification of Rocks.

By Professor T. G. Bonney, M.A., F.R.S.

THE two important papers by this accomplished veteran of science, which have appeared in the American Journal of Science (vol. xvi. November and December, 1878) [noticed in this present number of the Geological Magazine pp. 222–225], though, as might be expected, of the highest value, are in one or two respects, as it seems to me, open to question. Professor Dana approaches the subject as a chemical mineralogist: I venture to criticize as a field geologist who checks his conclusions by using the microscope.

There is, however, one point on which I would first venture to express my hearty concurrence with his remarks—namely, upon the impossibility of drawing hard and fast lines of distinction between rocks belonging to different geological ages. Lapse of time of course will bring about certain mineralogical changes, such as the formation of epidote, viridite, chloritic minerals, and various carbonates, or of hornblende in augitic rocks; or again, under certain circumstances, the production of tourmaline, lithia mica, etc. In short, the present condition of a rock may be said to be the result of two independent variables—external agents and time—and (within limits) the same result may come from either of these being large in comparison with the other. For instance, I have examined rhyolites, felsites, basalts and serpentines of very different geological ages, and have found it impossible to draw any important lines of distinction between them.

Still, while granting this, there may be advantages in retaining such a term as diabase, though we admit the rock's former identity with dolerite, and cannot draw a hard and fast line between the two. The latter difficulty does not meet us here only in Lithology, and it is convenient to have a term to denote varieties which have undergone marked alteration. Some geologists, I have observed, seem to forget that igneous rocks, as well as sedimentary, have their metamorphic representatives, and as a rule text-books do not sufficiently call the student's attention to this point.

With reference to Professor Dana's remarks on trachyte and felsite, it seems to me that, while admitting the chemical identity and common origin of both, we may conveniently take the presence of a glassy base as characteristic of the one, and of a micro- or crypto-crystalline ground-mass of the other. It is true that the latter may have resulted from subsequent devitrification, and a rock once glassy may have become cryptocrystalline. In that case, however, where we are convinced of the fact, we may either call the rock a devitrified rhyolite, and place it among the metamorphosed igneous division, or coin a single name to express the fact of change.

Professor Dana criticizes the use of the term 'gabbro.' It is quite true that there has been some uncertainty in this, and that the Italian petrologists call 'granitone' the rock to which the Germans apply the name gabbro. It is also true that gabbro is closely allied to dolerite, and that diallage is only a variety of augite; still, as this gabbro is a rock of a very definite appearance in the field, and seems to be of rather a different habit from dolerite,[1] which shades off through anamesite into the finer crystalline basalts (I think a revision of terminology needed here), the name appears to be useful. As regards euphotide and the so-called saussurite, I cannot altogether agree with Prof. Dana. I have examined a good deal of this rock in the field and microscopically, and have no doubt the mineral is only an alteration product from labradorite or anorthite, and the rock simply an altered gabbro. In the field (and under the microscope) the felspar may be seen gradually altering into saussurite, and the pyroxenic constituent into some form of hornblende. It seems, then, to me that gabbro may conveniently be retained for the name of a rock closely related to dolerite, and euphotide applied to the metamorphosed variety.

Professor Dana is very severe on geologists (especially microscopists) for their use of the term plagioclase. I venture to think we have a defence. Doubtless plagioclase is only a synonym for triclinic felspar, but I think that its correspondence in form with orthoclase renders it a more convenient term. We do not regard a

[1] I have never seen gabbro except under circumstances which suggested deep-seated intrusion; it seems to be the analogue of granite.

rock as perfectly defined when we say it consists of "plagioclase and augite," and so forth; but we not seldom find that we must be satisfied with this; because even Professor Dana himself could give us no better definition. Let us grant that there be a typical albite, oligoclase, labradorite, and anorthite; that there may be rocks in which each one of these felspars alone occurs; still I maintain that they have a frequent habit of intergrowth, as in perthite, bytownite, microcline with albite, etc., and that in many cases they thus occur in rocks. Examination also of the analyses given by Professor Dana himself[1] shows that even among the type felspars there is great variety; and that when a felspar is a rock constituent we have no security against variation or intermixture of species; while in many cases the felspars occurring in rocks are so minute that it would be impossible for the chemist to separate them for analysis. Analysis of the rock as a whole often fails to give the desired response, because the chemical constituents which it reveals may enter into the composition of more than one of the minerals already known to be present; so that the investigator is in the position of a mathematician who is asked to solve an indeterminate equation. Under certain circumstances we can, indeed, feel sure that the plagioclase is either albite or oligoclase or both, under others that it is labradorite or anorthite or both; and it would perhaps be expedient to add after the term "doubtless *a* or *b* or a mixture of them," but we may be pardoned for avoiding the monotony of this constant repetition, and leaving this to be supplied by the intelligent reader.

Our position then, as workers with the microscope, is that while thankfully acknowledging the aid of chemical analysis, we do not feel bound to spend much time or money in determining the precise character of the felspar in every case, because we know from experience that not seldom the oracle gives an ambiguous response, or at best leaves us very nearly where it found us.

Accordingly we use the term plagioclase[2] (with the understood limitation) as the most definite permitted by the present state of science. It may be that ultimately we shall be able to form a rock group correspondent with each of the species of plagioclastic felspar; but I doubt it, and expect that we shall not do more than separate those containing albite and oligoclase from those containing labradorite and anorthite; though even then it is not impossible that the second and third of these may sometimes be associated.

My most essential difference, however, from Professor Dana relates to his proposed classification of rocks. In this he passes over the question of the origin of the rock, by adopting a purely chemical or mineralogical basis, and grouping metamorphic clastic with true igneous rocks. He also justifies this method of classification by pointing out that true massive crystalline rocks need not necessarily be igneous,

[1] A System of Mineralogy, pp. 337–361 (ed. 1868).

[2] It is no doubt inconvenient that the species microcline has been discovered since the adoption of the term plagioclase; but we may avoid this difficulty by agreeing that the term plagioclase shall be used as a symbol for the group of soda and lime felspars—the character of the other species being so exceptional, and its relations to orthoclase being in most respects close.

and schistose rocks not necessarily metamorphic clastic. Within limits there is truth in this statement; but the qualification is all-important. I venture then to inquire whether Professor Dana has carefully studied the microscopic structure of these two groups and found that there is no difference in this respect between massive igneous and massive metamorphic clastic rocks, or between schistose igneous and schistose clastic rocks. This is a question to the study of which I have devoted much time both in the field and with the microscope; and mostly with this result—that in the former case not seldom the distinction was plain enough when sufficient pains were taken in looking for it; in the latter it was usually very marked. Hence, notwithstanding the weight of Professor Dana's authority, I venture to protest against any system of classification which sets at naught the distinction between a sedimentary and an igneous rock. There may be cases where metamorphism has been carried so far that the distinctive characters of the former rock are lost, but the evidence in favour of this is certainly far less satisfactory than it is commonly asserted to be, and (in the present state of our knowledge) to assume that such cases exist will, I think, encourage sloth in research and be a backward rather than a forward step in science.

There is also, from his own point of view, another serious objection to Professor Dana's classification. He draws a very marked distinction between the potash-felspar series (including leucite) and the soda-felspar (including nepheline). But while not denying the utility of this, in part, we must remember that there are few potash-felspar rocks in which there is not some soda-felspar (including oligoclase), and that cases are not uncommon in which the one about equals the other in quantity.[1] Even Professor Dana, by his remark on the nepheline rocks (phonolites, etc.), virtually admits that the distinction can hardly be maintained; and further, what are we to say of the association of leucite and nepheline, and of the occurrence of these minerals with both orthoclastic and plagioclastic felspars? Again in Professor Dana's classification we have lherzolite grouped with eclogite, and serpentine with chlorite schist; simply because they contain no felspar, notwithstanding their great mineralogical and chemical differences.[2]

[1] It is not seldom hard to say (even after chemical analysis) whether a rock should be called a syenite or a diorite, a minette or a kersantite.

[2] Analysis of eclogite (garnet and omphacite, with quartz, disthene and mica) from Eppenreuth. $Si\,O_2=57{\cdot}10$ $Al_2\,O_3=11{\cdot}66$ $Fe_2\,O_3=2{\cdot}84$ $Fe\,O=3{\cdot}22$ $Mn\,O=0{\cdot}31$ $Mg\,O=6{\cdot}37$ $Ca\,O=13{\cdot}80$ $K_2\,O=0{\cdot}81$ $Na_2\,O=2{\cdot}21$ $H_2\,O=0{\cdot}54$. Analysis of lherzolite (olivine, enstatite and diopside with picotite) from Kalohelmen. $Si\,O_2=37{\cdot}42$ $Al_2\,O_3=0{\cdot}10$ $Mg\,O=48{\cdot}22$ $Fe\,O=8{\cdot}88$ $Mn\,O=0{\cdot}17$ $Ni\,O=0{\cdot}23$ $H_2\,O=0{\cdot}71$. (Von Lasaulx, Elem. der Petrog.) Analysis of Serpentine (from Cornwall). $Si\,O_2=38{\cdot}50$ $Al_2\,O_3=1{\cdot}02$ $Mg\,O=36{\cdot}40$ $Ca\,O=1{\cdot}97$ $Fe_2\,O_3=4{\cdot}66$ $Fe\,O=3{\cdot}31$ $Ni\,O=0{\cdot}59$ $H_2\,O=12{\cdot}35$ $Fe\,S=0{\cdot}41$. Undecomposed residue $=1{\cdot}37$. (Q.J.G.S. xxxiii. 925). Analyses of Chlorite schist variable; these are two given by Zirkel (Petrog. i. 311) (1) $Si\,O_2=31{\cdot}54$ $Al_2\,O_3=5{\cdot}44$ $Fe_2\,O_3=10{\cdot}18$ $Mg\,O=41{\cdot}54$ $H_2\,O=9{\cdot}32$ (2) $Si\,O_2=42{\cdot}08$ $Al_2\,O_3=3{\cdot}57$ $Fe\,O=26{\cdot}85$ $Mn\,O=0{\cdot}59$ $Ca\,O=1{\cdot}04$ $Mg\,O=17{\cdot}10$ $H_2\,O=11{\cdot}24$. In such a grouping, even chemistry, as it seems to me, is fairly thrown overboard.

In short, as it seems to me, the classification of rocks must not be attempted by relying on evidence obtained in the field, with the microscope, or from the laboratory alone. Sometimes, it is true, the first will teach all that it is really important to know; commonly, however, we shall have to appeal to the second source of information, and not seldom we shall obtain from the third the solution of a difficulty which the other methods have failed to answer; but this last is rather a court of appeal than a court of first instance, and one which will not so much reverse the judgments of its predecessor as decide points which had been of necessity reserved. Or, to put it otherwise, and perhaps more accurately, the chemist is called in, like an expert, to settle certain questions, but there are many others with which he is not competent to deal. Professor Dana, as I venture to think, notwithstanding his own extensive learning as a geologist, places too much reliance on chemical evidence; and thus, while aiding in the destruction of certain idols which have a detrimental effect in Science, has set up others in their stead which would be as hurtful to its progress.

V.—Post-Tertiary Geology of Cornwall.[1]

By W. A. E. Ussher, F.G.S.

(Part III.—Continued.)

The Raised Beaches and Associated Deposits of the Cornish Coast.

15. St. Ives.

a. On the east of Carrack Olu Point, a bed of pebbles, 1 foot thick, is shown under Head, at from 2 to 5 feet above high water. The greenstone composing the Point is capped by a Head of yellowish-brown loam with angular fragments of greenstone.

b. In the bay east of the above, near the north part of St. Ives, the section is as follows:—

Head, with large angular fragments	5ft.	0in.
Impersistent strip of yellowish-brown loam.		
Head, loam with a few subangular fragments, and boulders toward the base	4ft.	0in.
Olive and yellowish sand with occasional pebbles	10ft.	0in.

At base about 5 feet above high water; resting upon dark bluish slaty grit with numerous joints.

c. On the north part of St. Ives Island, the greenstone is capped by a Head of angular greenstone fragments from 10 to 15 feet in thickness.

d. Mr. Whitley (Journ. R. Inst. Corn. No. 11, p. 184) gives the following section of the raised beach in Porthgwidden Cove, St. Ives:

Greenstone soil, upon Head of large angular blocks of hornblendic rock. Fine sand and loam; upon pebbles of hornblendic rock, quartz, granite, and a few worn flints, mixed with sand, and containing layers of fine brown sand	About 20 feet thick.

The base of the deposit is given as 5 feet above high water.

[1] Continued from the April Number, p. 172.

16. Gwythian and Godrevy.

a. Near the southern end of Black Cliffs the slates are capped by a Head of brown clay with angular stones, and a few quartz pebbles at its base.

b. South of Ceres Rock, greenish grey slates are capped by a Head of greenish grey clay, probably resulting from their decomposition.

c. West of Gwythian; cliff-section—

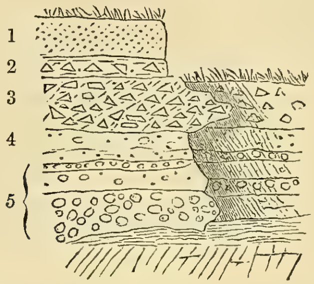


Fig. 3.—Near Gwythian. Vertical scale 1 inch = 12 feet.

1. Blown sand	2ft.	0in.
2. Brownish loam with angular slate fragments	1ft.	0in.
3. Agglomerate of angular slate and quartz stones in a consolidated matrix of small angular pieces of slate	3ft.	0in.
4. Fine brownish sand, consolidated in places, containing a few pebbles	2ft.	0in.
5. Three beds of pebbles and subangular stones of slate and quartz, with occasional pieces of flint in the lower bed. The beds are 4in., 1ft., and 2ft. in thickness, respectively	3ft.	4in.

d. Near the above, the Head consists of grey loam with angular slate stones of small and average size. The pebble deposits occur in two layers, separated by a seam of brown sand. The base of the gravel is about 5ft. above high water.

The following observations of the Cliffs of Godrevy commence at a point about three-quarters of a mile to the south of Godrevy Island.

e. The section, partially obscured by sandy debris, consists of—

Head, yellowish and grey loam with small angular stones, and occasional large angular quartz fragments, resting unevenly	10ft. to 20ft
upon—fine olive brown sand	5ft.
Coarse grey sand with pebbles and subangular fragments of slate and quartz, the former sometimes large	5ft.
Consolidated coarse blackish sand with small pebbles and subangular fragments, and a few large pebbles...	variable.

At base 5 to 8 feet above high water.

f. The pebble band is stained blackish, it is from 6 inches to 1 ft. thick, and about 6 feet above high water. At this point angular and subangular fragments, some large, are associated with the pebbles in a coarse impure sand matrix.

g. Two beds of coarse blackish and reddish-brown consolidated sand, containing pebbles, etc., of slate and quartz, 3 feet in maximum thickness, and 6 feet above high water at their base, are capped by angular Head. The upper bed forms the roof of a cavern in the slates. (Fig. 4.)

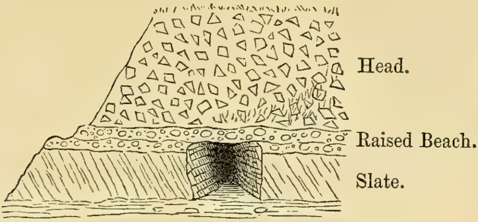


Fig. 4.—Godrevy. Vertical scale—1 inch = 24 feet.

h. A portion of the consolidated raised beach is visible on the foreshore resting upon two bosses of a waterworn slate reef. The denudation of the reef has scarcely affected the unsupported part of the under surface of the beach. (Fig. 5.)

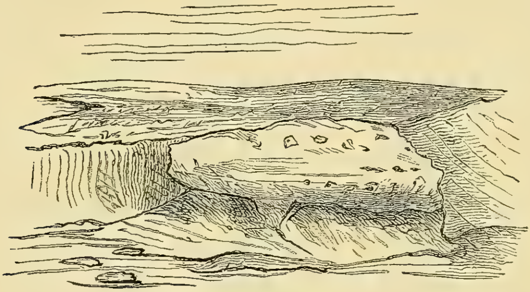


Fig. 5.—Godrevy Beach.

Portion of Raised Beach resting on bosses of Slate isolated from the main cliff.

i. Toward Godrevy Island the beach consists of coarse blackish consolidated sand with pebbles, more gravelly at the base, 4 feet thick, under thick beds of consolidated buff and grey sand with pebbles disseminated through the lower parts.

j. Dr. Paris (T. R. G. S. Corn. vol. i. p. 7) noticed a mass of sand near Godrevy Island, containing whole shells and slate fragments, 12 to 20 feet thick, and 100 feet in length.

k. Dr. Boase (T. R. G. S. Corn. vol. iv. p. 469) described a bed of pebbles above high water, at Godrevy Point and around Fistral Bay, overlain by a bed of testaceous sand; under "transported but unaltered debris," in one place (*op. cit.* p. 309) described as 20 feet of ferruginous clay with angular fragments (local), thinning out landwards as the ground rises.

l. Mr. Whitley (Journ. R. Inst. Corn. No. 11, p. 184) gives a section of the cliffs under Godrevy Farm from top to base.

Brown loam soil	6in. to 18in.
Clay and loam with numerous angular fragments of quartz...	6ft. to 16ft.
Sandy loam mixed with siliceous sand, and portions of a bed	

of contorted slate (believed by Mr. Whitley to have been pressed into the bed by ice). ... ...
Red and white siliceous sand, of quartz grains partially rounded.
Boulders of blue grit, granite, quartz, vesicular trap (as at St. Minver).
Slate and a few worn flints in sand cemented by the oxides of iron and manganese.

m. De la Beche notices (Report, p. 426) the old dunes of consolidated sand, between Gwythian and Godrevy Head, which he distinguished from the underlying raised beach.

17. Observations of the Fistral Bay Cliffs made here and there proceeding northward.

a. South end of the Bay (section obscured in places). Coarse brown semi-consolidated sand, with planes resembling bedding and false bedding, containing occasional lines of small angular slate and quartz fragments, 20 feet thick, seems to underlie Head, shown in a receding part of the cliff. At the base of this old blown sand, a trace of blackish coarse consolidated sand binding pebbles of slate and quartz is visible at from 4 to 5 feet above high water.

b. The basement beds consist of gravel of small quartz pebbles, with fair-sized quartz and slate pebbles, and large subangular slate fragments in blackish sand, 1 foot to 18 inches thick, with few pebbles and of a brick-red colour in places; overlain by fine blackish and reddish brown sand with a few pebbles through it, from 2 to 3 feet in thickness.

c. The basement beds are represented by two beds of small quartz and slate pebbles and subangular stones, 6 inches and from 6 inches to a foot thick, respectively, separated by 18 inches of coarse blackish sand.

d. Coarse consolidated sand of slate and quartz and comminuted shells rests on a pebble bed 2 feet thick, and at base 5 feet above high water. The pebbles are of slate, quartz, and occasionally flint; quartz predominates; the matrix is coarse grey sand.

e. Cliff-section toward the north of the Bay—

Recent blown sand	3ft.	0in.
Sandy soil with angular fragments of slate	2ft.	0in.
Buff loam with angular stones and boulders	2ft.	0in.
Buff sand	1ft.	0in.
Coarse and fine gravel of quartz, dark grey grit, slate and occasionally flint	4ft.	0in.

f. Near the above old blown sand is shown consisting of brown consolidated sand in laminæ about one-eighth of an inch thick, containing pebbles for 4 feet upwards from its base, which is about 10 feet above high water.

g. About 100 yards from the above a trace of consolidated sand binds pebbles at about a foot above high water. Old consolidated blown sand is shown in the cliff above; overlain by Head, capped by recent blown sand. Two whole shells of *Patella* were found near the base of the old blown sand, which forms a tough, bedded rock, hardening on exposure to the weather.

h. Dr. Paris (T. R. G. S. Corn. vol. i. p. 7) described the old beaches of Fistral Bay and New Quay as a horizontal bed of pebbles, 10 to

12 feet thick, containing whole shells and slate fragments cemented in sand, resting on slates, and supporting immense heaps of drifted sand.

i. De la Beche (Report, p. 427) describes the Fistral raised beach as rolled pebbles, often large, mixed with smaller gravel and sand, overlain by alternations of fine gravel and sand (the layers being unequally consolidated), capped by sand, becoming mingled with rock fragments, near the extremity of the dunes on the north and south.

j. Mr. Pattison (T. R. G. S. Corn. vol. vii. p. 50) mentions the intersection of the Fistral raised beach by a lead lode, in the middle of the Bay. He describes the present beach as "fine sand and an abundance of shells; it exhibits no pebbles save those derived from the ancient beach."

18. New Quay.

a. On the east side of Towan Head, a trace of black consolidated sand with pebbles is visible at about 6 feet above high water.

b. On the west of New Quay Pier, the section consists of coarse yellowish-brown consolidated sand, chiefly made up of comminuted shells, with a few shells of *Helix*, containing angular, subangular, and rounded stones and boulders of quartz and slate (a granitoid fragment was found) at the base; upon coarser sand with well-rounded fragments resting on a narrow rocky platform 6 feet above high-water mark.

c. Dr. Boase (T. R. G. S. Corn. vol. iv. p. 259) noticed a bed of shelly sandstone, on the north of New Quay signal station, containing fewer shells than at Fistral Bay; the lower part, just above high-water mark, being consolidated into a conglomerate.

d. De la Beche (Report, p. 427) gives a section on the east of Look-Out Hill, New Quay, of an ancient beach of rounded slate pebbles agglutinated by consolidated sand, some feet above the sea-level; capped by layers of sand of comminuted sea-shells consolidated in the lower parts; under a Head of angular fragments from the rocks of the hill above.

19. Between New Quay and Padstow.

a. A thin capping of Head visible on part of Trevelga Head Island.

b. To the west of Tregurrian, Head of angular and subangular slate and quartz stones is shown in the cliffs, under greyish sandy soil.

c. West of Trenance (N. of Mawgan Porth) the Head consists of brown loamy clay with large quartz boulders, and small slate and grit stones.

d. At the north end of Treyarnon Bay the low cliffs are capped by 6 inches of angular quartz and slate stones, under brown clay, one foot thick.

e. The cliffs bounding Constantine Bay, for about three-quarters of a mile, seldom exceed 7 feet in height. Opposite Constantine Island the cliff is composed of—

Blown sand with a layer of broken *Mytili*, and whole *Patellæ*, finer in the lower part, and containing angular pieces of slate, and fragments of shells, as above	4 ft. 6in.
upon—coarse quartzose sand with rounded grains	1ft. to 2ft.

resting on slates at 6 feet above high water.

f. Near the centre of Perleze Bay a few quartz and slate pebbles are present, under blown sand, at about five feet above high water.

g. The cliffs of the cove north of Trevone (2 miles west of Padstow) are from 5 to 15 feet high, and occasionally capped by coarse brownish sand, giving place to dark brown clay with angular slate fragments, and an occasional quartz pebble. The ground slopes upward for a quarter of a mile very gradually.

20. Between Padstow and Tintagel.

a. On the cliffs of Bray Hill, near St. Enodock, yellowish and grey, thin bedded, consolidated sand of comminuted shells, containing shells of *Helices*, is visible, at base 5 feet above high water.

b. In one place the following section occurs under 2 feet of recent blown sand:

Consolidated sand	6in.
Dark brown loam, containing angular fragments of quartz, slate and grit	2ft. to 3ft.
Upon greenish grey slates with quartz veins.	

c. Near the mouth of the St. Enodock Valley, a bed of consolidated sand, one foot thick, containing land shells and angular fragments of slate, is capped by recent blown sand, and rests on red and green banded slates at 8 feet above the present beach.

d. At the stream mouth between Porteath and Trefan Head, Head, of angular stones in brown and yellowish loam, has a stratified appearance in the distance, owing to the sizes and dispersion of the fragments and their partial absence in places. The stream has cut a steep bank at the mouth of its gorge, which exposes 20 feet of Head—brown loam with angular slate and quartz stones, roughly horizontal in arrangement.

e. By the mouth of the stream west of Port Isaac, between Roscarrock and Lobber Rock, 20 feet of Head is shown, consisting of angular fragments of slate and quartz in brown loam.

f. Near Chapel Rock the slates have been cut into reef platforms or shelves, in places, at about high-water level.

g. At the mouth of the stream gorge west of Dannon Chapel, 10 feet of Head is shown, consisting of brown loam with angular slate and quartz stones.

21. The Scilly Isles.

Mr. Carne (Trans. R. G. S. Corn. vol. vii. p. 140) mentions the occurrence of redistributed granitic matter, called "secondary granite," on Rat Island, at Piper's Hole in Tresco, and Piper's Hole in St. Mary; in both the latter caverns it forms the principal part of the roof, and contains boulders or rounded masses of perfect granite, some rather large.

General Conclusions.

Head.—The position of the stony loam or Head in sites where no modern talus could rest; the denudation it has undergone, and its frequent presence on the cliffs; prove its accumulation to have taken place subsequent to the formation of the raised beaches, yet considerably anterior to the prevalence of the present climatal conditions. It marks, as Mr. Godwin-Austen (Q.J.G.S. vol. vii. p. 122) says, "A time when the degradation of the surface proceeded much more rapidly, and when fragments of rock far exceeding the motive power of any rainfall were conveyed down slopes along which only the minutest particles of matter are now carried" (*vide* 9 *c*). Such conditions of long-continued subaerial waste are likely to have prevailed, as Mr. Godwin-Austen suggests (Q.J.G.S. vol. vi. p. 93, etc.), during a greater elevation of the (South) West of England.

The rough appearance of stratification sometimes noticeable in the Head [(1) through the horizontal lie and apparent regard to gravity in distribution of its contained fragments, *vide* 3 *b*; 5 *b*; 13 *a*; 20 *d*; (2) through strips of loam or clay without stones, as in the higher cliffs bordering Pra Sands, and 15 *b*; (3) through percolation of water carrying down overlying substances to a certain horizon, as 17 *e*; (4) through distribution of colouring matter, as 5 *b*, 13 *a*] may in many cases be due to fluviatile deposition, to which Mr. Godwin-Austen referred the Head at Swanpool (5 *d*) and other places.

We cannot suppose that no fluviatile deposits were formed during this period of subaerial waste; judging from the pell-mell distribution of angular fragments in the torrential gravels of the present streams, in their higher reaches, it is only reasonable to expect that similar deposition would then have taken place on a much larger scale, and that its traces would be found in the present area of the county which would only represent the highlands of its former extension.

Raised Beaches.—The general consolidation of the old beach materials, occasionally into a very hard rock (*vide* 6 *c*; 16 *g*, *h*; 18), renders their detection, even as fragments on a level with the surface of the present beach, comparatively easy; where, however, the process of consolidation was interfered with by the accumulation of the Head, the beach material seems to have been swept away, and in some cases to have left traces in occasional pebbles at or near the base of the Head (*vide* 5 *a*; 6 *a*; 16 *a*; and perhaps 19 *g*). Even where the raised beach is well developed, the upper part has been sometimes mingled with the base of the overlying talus (13 *b*). Angular fragments are occasionally found in the raised beaches (16 *f*). The above observations serve to explain the appearance of beach material on Head, S. of Perranuthno (9 *g*), as, in an adjacent section (9 *g*′), the Head is represented by pebbles and subangular fragments. On Bray Hill (20 *b*), 6 inches of consolidated sand rests on 2 to 3 feet of Head; but the latter is represented in an adjacent spot by consolidated sand with angular fragments of slate, and land shells (20 *c*); so that the old sand drift may have taken place on the beach platform after a little talus had been shed upon it during the earliest symptoms of elevation.

It is often difficult, where old consolidated blown sands occur, to distinguish their junction with underlying raised beaches, as pebbles and fragments of *Mytili*, *Patellæ*, etc. (16 *i*; 17 *f*, *g*; 18) may have been cast upon the dunes by storm waves; for their presence and linear arrangement in recent blown sand (19 *e*) would seem to be due to protracted gales from the same quarter.

Being chiefly composed of comminuted shells, the percolation of water through the old dunes would best explain their consolidation. Dr. Paris (T.R.G.S. Corn. vol. i. p. 7), in addition to this, gives two other possible modes of consolidation, viz., by water charged with pyritical substances, or by ferruginous infiltration.

The absence of organic remains in the majority of the Cornish raised beaches has been ascribed to Arctic currents (Godwin-Austen, Q.J.G.S. vol. vi. p. 87), which I think very probable. It also suggests the possibility that many of them may have been deposited by rivers, or in estuaries, whose seaward banks have been swept away. Some of the boulder beds mentioned by Messrs. Carne and Henwood are at too great heights to be regarded as raised beaches, and may more reasonably be referred to far older fluviatile deposition. If the adit mentioned by Mr. Henwood (12 *b*) cut through a continuation of the worn boulder beds of Porth Just and Pornanvon to a thickness of 60 feet, the boulder beaches of these localities must be regarded as anterior to the raised beaches. In the formation of the old beach cliffs at the termination of a long period of subsidence, fluviatile deposits (thrown down before, and during, the initiation of the present lines of drainage) would have been truncated, so to speak, and exposed at different heights upon the cliffs, just as we find old river gravels exposed on the secondary cliff-line of Devon.

Again, during the elevation of the old beaches, the existing river channels would have been deepened, and river deposits formed in the breaches of the old cliff-line, to be redistributed by the sea in its recent advance. How far boulder gravels and unfossiliferous raised beaches (provisionally so called) may be referred to either of these periods of fluviatile action it is impossible to say, without a searching investigation of each particular deposit with references to its surroundings.

The local elevation of the raised beaches cannot be correctly measured by the height above high water of their remains. For such an estimate ignores the original thickness of the beaches, and postulates an identity in the local rise of tide during the raised beach formation and at present. The latter supposition is improbable when we take into account—

1stly. The destruction by the sea during elevation (of the old beaches) of such inequalities as may have proved obstacles to the stream of tide.

2ndly. The modification the raised sea-bed would have undergone through subaerial agencies.

3rdly. The probably different relations of land and sea in other parts of England, and on neighbouring coasts during the formation of raised beaches in the S.W. counties.

4thly. The subsequent modification of the old coast-line.

Mr. Pengelly (Trans. Dev. Assoc. part v. p. 103) points out the fallacy of supposing—that all contemporary raised beaches are on the same level, and the converse—that raised beaches on the same level are necessarily contemporaneous. The cautions given show the danger of laying stress upon individual observations which may be taken where the beach was left very thin, or at different parts of its seaward slope.

The base of the Cornish raised beaches above high-water is shown by observations to average 5 feet; such cases as Pendeen Cove (14); Tremearne (9 *b*); Nanjulian (11 *c*); Porth Just (12 *a*); being exceptional. Taking the thickness of the old beaches at 15 feet as a maximum, the average subsidence indicated by them would be from 12 to 20 feet below high water.

De la Beche (Geological Manual, p. 157) gives a section of the successive faces (indicated by dotted lines) that the degradation of a cliff composed of Head upon raised beach would be likely to exhibit (see Fig. 6).

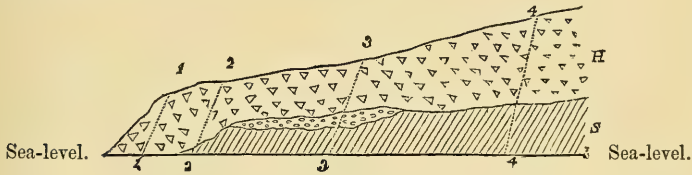


Fig. 6.—H, Head, concealing a raised beach, resting upon slate, S, above the sea level.

The raised beach platform has been cut too far back to allow of such cliff faces as 1 and 2. Exceptions to this rule may be furnished by the low tract at Spit Point near Par; the lowlands of St. Keverne (7 *c*); the flattish tract covered by blown sand between Constantine and Perleze Bays, if the waterworn sand (in 19 *e*) is a trace of raised beach, or rests on an old beach platform; the gently sloping tract bordering the coast near Trevone (19 *g*).

The cliffs bordering a part of Pra Sands are wholly composed of Head to a height of 60 feet from the present beach; but as Head rests on a portion of raised beach on an adjacent promontory, on a platform 5 feet above high water, the old beach platform may in this instance have been broken up by fluviatile agencies prior to or during the accumulation of the Head; or the original surface of the platform must have been most irregular. Such cliffs as Nos. 3 and 4 are by far the most general sections on the Cornish coast, which has been in very many places cut too far back to show either raised beach or Head.

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

VI.—Geology of the Isle of Man.

By G. H. Morton, F.G.S.

In the Geological Magazine for 1877, Dec. II. Vol. IV., pp. 410, 456, there is an article on the "Geology of the Isle of Man," by Mr. Henry H. Howorth, to which I desire to call attention. Most geologists are aware that the late Rev. Joseph G. Cumming, M.A., F.G.S., wrote a work entitled "The Isle of Man," in 1848, and that it contains a geological description of the island. In this work, and in a paper by the same author, published in the "Journal of the Geological Society" for 1846, vol. ii. p. 317, there is a minute description of the Carboniferous formation developed at the south of the island, near Castleton, illustrated by maps and sections. Mr. Cumming gives the order in which the subdivisions occur from the top downwards as follows:—

Posidonian Schists.
Poolvash Limestone.
Lower Limestone.
Old Red Conglomerate.

He describes each of these subdivisions, the volcanic ash interstratified with the Poolvash Limestone, and gives a list of 222 fossils found by him in the Carboniferous Limestone, showing the range of each species. The Old Red Conglomerate at the base of the limestone is minutely described, and the area it covers is shown on the geological maps. Several papers have since appeared on the geology of the island, but one entitled, "A Sketch of the Geology of the Isle of Man," by Mr. John Horne, F.G.S., of the Geological Survey of Scotland,[1] includes a concise account of the Carboniferous Limestone, and confirms the arrangement of the subdivisions adopted by Mr. Cumming; indeed, no one, excepting Mr. Howorth, has challenged the correctness of his conclusions, which have the appearance of being the result of long-continued and careful observations.

Mr. Howorth states that he spent three long days in examining the deposits in the south of the island, but principally the Old Red Conglomerate. That Mr. Cumming was "entirely erroneous," and that the Old Red Conglomerate does not underlie the Carboniferous Limestone, but is simply an overlying deposit of Boulder-clay, and remarks that "A conglomerate consisting almost entirely of limestone boulders, imbedded in a matrix of pulverized limestone, lying immediately in contact with beds of limestone, cannot well by any process of reasoning be made into an Old Red Conglomerate." Mr. Howorth searched carefully the various points where the deposit occurs at Langness, but could find no evidence of it being overlain by the limestone; and at Cushnahavin he says he actually saw the latter reposing on the underlying Silurian strata. He concludes the conglomerate to be a consolidated Boulder-clay, and that the trap-dykes with the volcanic vent at Scarlet Point were posterior to the Conglomerate, and finally remarks that "We thus add another remarkable example to the list of volcanos active within the British seas in Post-Tertiary times."

During last summer, I, like Mr. Howorth, had three days in the Isle of Man, which I devoted to the examination of the Carboniferous Limestone and the Conglomerate at its base. Having read Mr. Howorth's paper in the Geol. Magazine, I at once endeavoured to ascertain the stratigraphical position of the Conglomerate, and I found the difficulty of doing so somewhat over-estimated, although the shore along the outcrop is only exposed at low water and some-

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

what obscured by stones and sea-weed. I, however, found without difficulty a spot on the shore, north of the copper mine, where the Old Red Conglomerate clearly dips below the Carboniferous Limestone, and trap-dykes traversing both alike. I found the boulders and pebbles in the Conglomerate to be quartzite instead of limestone —at least all I could find were quartzite, and many I tried with acid so as to be perfectly sure about them. In colour they certainly resemble the limestone in the vicinity, but they still more nearly resemble the quartzite interstratified with the Silurian in close proximity.

Mr. Howorth says he found no Old Red Conglomerate, but the limestone resting directly on the Silurian at Cushnahavin, but Mr. Cumming describes how the limestone is faulted against the Silurian at that place so that the appearance may easily be explained, and he states that the Conglomerate occurs at a little distance, about 10 feet below high-water mark. I found the top of it under the limestone just as described, and have great confidence in the correctness of Mr. Cumming's sections, though I had not time to follow them across the whole area. I need scarcely remark on the improbability of trap-dykes intersecting Boulder-clay, and volcanic vents in the British Seas in Post-Tertiary times.

Mr. Howorth says he was not at Peel, and that his arguments only apply to the south of the island; but I visited that locality and found the Old Red Sandstone to be interstratified with a conglomerate in steep cliffs dipping towards the sea at a considerable angle. Mr. Cumming refers to numerous blocks of limestone thrown up by the waves along the shore, and concludes that there are beds of it on the dip at no great distance from the land. He also states that limestone was formerly obtained and burnt in kilns, though unable to determine whether it was an interbedded cornstone or an overlying limestone. However, there seems no doubt that the Red Sandstone with conglomerate at Peel is of the same age as the Conglomerate about Castleton. Mr. Howorth states that he is only an amateur geologist, and had only three days in the district; but Mr. Cumming resided in the island, being Vice-Principal of St. John's College—within gun-shot from the Old Red Conglomerate—and it is very improbable that he made any mistake in its geological position—however nearly it may resemble some local Boulder-clay. It is surprising that Mr. Howorth's paper has not been noticed; for, being the most recent communication on the subject, it tends to throw doubt on the stratigraphical order of the Carboniferous series in the Isle of Man—and the Old Red Conglomerate must be considered to be the base of it.

In conclusion, I recommend those interested in the subject to read Mr. Horne's paper, for he very fully describes the Old Red Sandstone of Mr. Cumming, which he considers to represent the Calciferous Sandstone series of Scotland, and consequently can entertain no doubt as to its position being beneath the Carboniferous Limestone.

Liverpool Geol. Soc., *Feb.* 10, 1879.

VII.—The Fossiliferous Clay Beds overlying Basalt, Lough Neagh, and the Geological Age of that Lake.

By Edward T. Hardman, F.C.S., etc.

I REGRET that I have not had an earlier opportunity of replying to a paper in the Geological Magazine for February, p. 62, by Mr. William Swanston, F.G.S., on the above subject. I shall now try to compress my remarks into the smallest possible space.

1. With regard to the Fossiliferous Clays in the Crumlin River:—Mr. Swanston is mistaken in supposing that the discovery of shells in these beds "proved to the satisfaction of the author (myself) and Professor Hull, F.R.S., . . . that the beds were undoubtedly of Pliocene age." Here Mr. Swanston has reversed matters. On the contrary, this conclusion had been arrived at two years before, and at the Belfast Meeting of the British Association I stated my conviction, chiefly from stratigraphical evidence, that the Lough Neagh Clays were of Pliocene age, and the similarity of the beds led us to the conclusion that the *shells might be* of Pliocene age.

2. I never led it to be believed that I was "convinced" that the shells in question "belonged to a species of *Unio*." And even before suggesting that "they appear to belong," etc., I had consulted Mr. W. H. Baily, F.G.S., whose authority as a Palæontologist I need not here enlarge upon. Moreover, not being *convinced* by the examination of a few mutilated specimens, I even pointed out the necessity for a thorough examination of the specimens on the spot, to which hint doubtless Mr. Swanston is indebted for his collection.

3. I am at a loss to know if the opinion of Dr. Gwyn Jeffreys, F.R.S., is positive or conjectural. Such a phrase as "I can come to no other conclusion" is somewhat ambiguous. There could be but little difficulty in determining absolutely the common mussel as it occurs in drift.

4. Here it occurs to me: Can Mr. Swanston and I be referring to exactly the same locality? In the section I described there occurs positively no Boulder-clay whatever; though there is abundance of it both higher up and lower down the river, from which Mr. Swanston may have obtained his shells. But the clays resembled in every respect many of the beds of undoubted lacustrine clay of Lough Neagh, and were perfectly similar to those found not far distant on the Glenavy River; and also to many of the beds used for pottery manufacture to the south of the lake. Furthermore, the shells I noticed are extremely thin and fragile, hardly thicker than a piece of notepaper. They appear in every way suited for the quiet waters of a lake, but seem ill-fitted to resist the stormy buffetings of a sea-shore. The clays in which they occur are deposits clearly formed on the ancient margin of the lake, as denoted by old shore-cliffs of basalt close by. Even granting that the shells be *Mytilus*, it would not be outside the bounds of possibility that the lake might formerly have communicated with the sea, as it is now only 48 feet higher; thus the shells might be true lacustrine fossils deposited before the Glacial period.

Although drift deposits are well exposed in the vicinity and along the shores of the lake, no similar clays are to be seen amongst them. And on the whole, without further investigation and more convincing proofs, I am unwilling to admit that the deposit I described can belong to the Glacial period, seeing that it resembles in every respect the lacustrine clays, while totally differing from the drift beds.

5. *Age and Mode of Formation of Lough Neagh.*—Even if we should be obliged to reject the lacustrine origin of the Crumlin deposit, I confess I cannot follow the argument by which as a *sequitur* Mr. Swanston endeavours to quash the theory formerly proposed by me with respect to the age of the lake. This particular deposit cannot affect that theory one way or the other. If there is anything geologically certain, it is that Lough Neagh occupies a depression primarily caused by large faults which occurred *after* the latest sheets of basalt we are acquainted with had been poured forth.[1] This is sufficiently clear from the fact that the upper basalt is brought down against the lower, as at Templepatrick and Shane's Hill. It is also capable of proof that the Lough Neagh clays (the lacustrine origin of which has never been doubted) are later than the basalt, and older than the drift, which covers them in many places. Also that they are the delta of one or more rivers flowing from the southwards after a considerable area of country had been denuded of the basalt which formerly extended at least as far as Slieve Croob and the Mourne Mountains. Mr. Swanston, however, prefers to consider the lake as of intra-Miocene age; and as a consequence of the supposed Glacial age of the Crumlin deposit —but why, I am unable to conjecture—places the Lough Neagh pottery clays as contemporaneous with the lacustrine iron-ore deposits of Antrim, etc. He forgets that first the Lough Neagh deposits are *proved* to be 300 feet thick. 2nd. That the depression of Lough Neagh is more than 1,700 feet, and that it would certainly have been filled up by the next flow of basalt. 3rd. That the faults around it, some of 500 feet, which must have altered the face of the country considerably, are post-basaltic. And last, but not least, that the Lough Neagh deposits are totally different in every respect from the ferruginous deposits of Antrim.

The iron-ore beds of Antrim were formed in a series of shallow depressions by the denudation of the basalt itself. By a well-known series of chemical changes the basalt yielded soluble carbonate of iron, which, being carried into these shallow "broads," was oxidised and deposited as hydrated oxide of iron, subsequently dehydrated. According to the freedom or otherwise of the lake from silt or mud, rich iron-ore, lithomarge or aluminous ore was produced. All these deposits are rich in iron, and are not of great thickness.

With these the Lough Neagh clays have nothing in common. They consist simply of clay, more or less sandy, usually very light

[1] For full details on this and the following statements see "On the Age and Mode of Formation of Lough Neagh," Brit. Assoc. Rep. 1874, and Journ. Roy. Geol. Soc. of Ireland, vol. iv. pt. iii. new series.

grey or nearly white, occasionally dark grey or purple, from organic matter or the material, probably Silurian slates, from which they were derived. Although they contain a few nodules of siliceous clay ironstone in some places—very sparingly—and not unlike those of the Coal Measures, the small quantity of iron the clays contain will be inferred when I mention that all qualities are largely used for the manufacture of tiles and coarse pottery; for which, of course, ferruginous clays would be utterly useless.[1] Yet of these clays Mr. Swanston pens the following remarkable passage, on the assumption that they are of the same age and origin as the Antrim iron-ores:—

"Should subsequent researches prove these to be the same, it may safely be inferred that one reason why the Lough Neagh beds still retain their clayey character is owing to the simple fact that the *later* outflows of Miocene basalt did not reach them, and convert them into iron-ores, etc., similar to those so largely developed to the east and north of Antrim" (!). The *simpler* fact that they are non-ferruginous clays is the easier mode of explanation. *Ex nihilo nihil fit.*

If the Lough Neagh clays were of intra-Miocene age, and formed in the same way and time as the Antrim ore deposits, they would be found resting only on basalt, or absent where basalt does not occur. They however overlap the previously denuded basalt, and their continuation is found in several places resting on Triassic rocks.

Mr. Swanston is doubtless unaware of these facts, which are, I need not observe, completely antagonistic to his doctrine as to the age of the clays. And but that I fear to trespass on the kindness of the Editor of the Geological Magazine, whose space is valuable, it would be easy to give numberless other facts as overwhelming proofs of the post-Miocene age of the Lough Neagh clays, and of the lake itself.

Returning to the Crumlin shells. I must now, at the cost of repetition, point out that even if they are hereafter proved to be Glacial fossils, such a matter can hardly be evidence in favour of the intra-Miocene age of the lake: yet this is apparently the conclusion to which Mr. Swanston's arguments would lead us.

With regard to the *silicified wood*, I can only say that it has never been found in any of the numerous clay-pits to the south of the lake. And in the only case where Barton records its existence *in sitû*, it may have belonged to the drift. Excavations and borings in the same locality in the true lacustrine clays revealed none of it; and the origin of this wood is a matter still enveloped in great obscurity.

VIII.—On Plagioclinal Mountains.

By Charles Callaway, M.A., D.Sc. (Lond.), F.G.S.

The object of this paper is to show that the received explanations of the structure of mountain chains will not account for the formation of certain Precambrian ranges, and to state facts in support of a new theory of the origin of some mountains. A brief summary of the ordinary views of the subject will first be necessary.

[1] The analysis of these clays, given by Sir Robert Kane, shows them to be remarkably free from iron.

Most mountain chains are produced by the puckering of the earth's crust into parallel flexures, and the greater systems consist of a combination of these earth-waves. Each wave usually rises higher, and the crests approximate more closely, towards the axis of the chain. The Alleghanies of North America well illustrate this structure. Towards the east, the anticlinals are squeezed up to such a height by lateral thrust that they sometimes fall over on one side, like an ocean wave rolling in upon a shallow shore. But, towards the Mississippi Valley, the waves gradually flatten out into low broad undulations. Of course, denudation has acted powerfully upon the flexures, by marine action during their emergence from the ocean, and by sub-aerial forces since their elevation. No trace of the original curved outline of the earth-waves appears in the shape of the ground. The tops of the anticlinals were planed off by the waves of the sea, and rivers have since scored and fretted the surface into a seemingly lawless irregularity.

But amidst this apparent disorder, one law is clearly seen. This law is that *primary mountain ridges run parallel with the geological strike.* A range sometimes consists of a denuded anticlinal; sometimes of a synclinal converted into a prominence by the erosion of the anticlinals on each side; sometimes of combinations of both, or parts of either. But in all these cases, the strike of the mountain chain corresponds with the strike of the beds of which it is composed. Amongst examples of this law which will at once occur to geologists, are the Pennine chain, the Cotteswolds, the North and South Downs, the Swiss Alps, and the Andes. The normal structure of mountains may be called *orthoclinal.*

The reason of this correspondence between geographical and geological strike is not far to seek. Take the case of an anticlinal mountain. Here the ridge is simply the upper half of a mutilated earth-wave. During the emergence of the land, the anticlinals were first exposed to the action of the sea. Notwithstanding the erosion of the ocean-waves, the anticlinal axes succeeded in raising themselves, though in a very mutilated state, into dry land. Subsequent sub-aerial action would score and carve the slopes of the saddle into ravines and valleys, but it would not interfere with its strike. Synclinal ridges are formed in a similar manner; but with one difference. During emergence, the waves plane off the top of the anticlinal, and expose softer strata which lie beneath. The anticlinals thus become lines of weakness, along which denudation works with great rapidity till it reaches a lower level than the synclinals, which stand up as ridges. The alternative between anticlinal and synclinal ridge is, then, mainly determined by the relative hardness of the strata. In both cases, the strike of the chain will be parallel to the original earth-waves, that is, to the geological strike.

In reconstructing portions of the geology of Shropshire, the writer has observed some remarkable exceptions to the above rule. The southern half of the county is grooved by a series of parallel valleys trending to the S.W. The intervening elevations, of course, strike in the same direction. These, taken in order from E. to W., are the Clee Hills, Wenlock Edge, the minor ridges of Chatwall and Hoar Edge, the Wrekin and Caer Caradoc chain, the Longmynd, and the Stiper Stones. Most of these elevations form parts of a great broken S.W. anticlinal, of which the Caer Caradoc and Wrekin chain is the axis. The escarpments to the E. of the axis face, of course, to the N.W.; the escarpments to the W. of the axis break down to the S.E. All the ridges follow the ordinary rule, except the Wrekin and Caer Caradoc chain, to which attention is specially directed.

This chain is nearly 30 miles in length, and is broken by three broad gaps of from 4 to 8 miles in breadth. The chief elevations, taken from the N.E., are Lilleshall Hill, the Wrekin range, Caer Caradoc range, and Wartle Knoll. The last, being of inconspicuous elevation and of doubtful structure, may be neglected. The other three agree in displaying the same peculiarity of structure. The beds of which they are composed *strike across the axis.*

Lilleshall Hill is one mile in length by one-sixth of a mile in breadth at the base. Its trend is S.S.W. The beds of volcanic ash of which it is composed strike W.S.W. The difference between the geographical and the geological strike is about 45°.

The *Wrekin* chain, consisting of four elevations, the Ercal, Lawrence Hill, the Wrekin, and Primrose Hill, is three miles in length by half a mile in its greatest breadth. It consists of alternations of lavas and tuffs dipping to the N., the ridge trending to the S.W. In this case also the divergence of the two strikes is about 45°. An inconspicuous elevation, lying two miles W. of the Wrekin, named *Charlton Hill,* ranges due N. and S. In this ridge is a band of conglomerate striking E. and W., the divergence of strike amounting to a right angle.

The *Caer Caradoc* chain is about six miles long by about half a mile in its greatest breadth. Its chief summits are the Lawley, Caer Caradoc, and the Ragleth. Its strike is to the S.W. The average strike of the grits, tuffs, and felstones which make up the chief part of the range is E. and W.; intrusions of greenstone sometimes twisting round the strike 20° to 30°, and, on the S.E. side of the Ragleth, causing it to coincide with the trend of the ridge. These disturbances are only local, the usual E. and W. strike being resumed at a distance from the disruptive masses. A great spur which springs from the S.E. side of the range, and juts out for two miles to the E., is composed of beds of grit, breccia, and felstone, which strike in the same direction as the spur.

It is clear that, with local exceptions, the bedded rocks of the Wrekin and Caer Caradoc chain strike across the axis at angles varying between 45° and 90°.

It would be evident, *à priori,* that such a mountain range could not be formed on the normal plan. The geographical strike bears no causal relation to the original earth-waves. It has been determined not by axes of upheaval, but by *parallel faulting.*

A great S.W. line of dislocation commences near Lilleshall Hill on the N.E.; passes through the Wrekin and Caer Caradoc chain; is continued to Stanner Rock and Hanter Hill, W. of Kington; passes under an anticlinal N.W. of Brecon; appears to sweep round to the W., and to be connected with the Precambrian ridge of St. Davids. In Shropshire it is a complex system of faults. There appear to be in all about six primary dislocations parallel to each other and to the mountain ridges. For our present purpose, we shall not require more than a pair of these.

Commencing with Lilleshall Hill, we find that it is bounded by faults on both sides. On the S.E., the Hollybush Sandstone (Caradoc in the Survey) has been thrown down; on the N.W., the lower beds of the Trias. The structure of the ground is the same in the Wrekin range, save that faulted bands of quartzite are interposed between the axial rocks and the Hollybush Sandstone and the Trias on either side. The Caer Caradoc chain is in like manner bounded by two nearly parallel faults. On the N.W., the lower slates of the Longmynd series rest against the axis; on the S.E., the Shineton Shales, the Hollybush Sandstone, and the Caradoc Sandstone are successively thrown down.

It is evident that in each case *a wedge of the solid crust* has been separated from the main mass by two nearly parallel faults, and thrust up through overlying Cambrian and Silurian strata. Or it is probable, in the case of the Wrekin at least, that the wedge was first pushed up in Pre-Cambrian times.

As the rocks of this chain consist, not of eruptive greenstones (according to the late Sir R. Murchison and the Geological Survey), but of bedded lavas, tuffs, grits, conglomerates, and other stratified material; and as they are flanked on each side by strata, some of which are at least as old as the Lower Cambrian; it is clear that these mountain ridges are of *Precambrian age.*

The writer has been greatly interested to find that certain other Precambrian elevations, described in recent times by Prof. Phillips, Dr. Holl, and Dr. Hicks, display a similar abnormal structure.

The *Malvern Hills* trend N. and S., but the schists and granitoid rocks of the chain strike across the axis in a S.E. direction. A great dislocation throws down Triassic sandstones against the eastern flank, and the author is convinced from a personal examination that the ridge is also bounded by a fault on the W. side. These rocks are still more ancient than those of the Wrekin chain. The range has evidently been formed in the same way. A solid slice seven miles long, composed of strata striking to the S.E., has been isolated by two parallel N. and S. faults, and pushed up as the original ridge out of which the Malvern Hills have been sculptured by frost and rain.

A third Precambrian ridge exhibiting a similar structure occurs at St. Davids, and has been described by Dr. Hicks. It extends for about two miles from the city to the S.W., and has an average width of rather less than a mile. It consists of quartziferous and granitoid rocks distinctly bedded, and striking across the axis to the S.E., that is, at about a right angle with the strike of the ridge.

This series has been named the Dimetian. It is flanked on both sides by a younger Precambrian formation, the Pebidian. In Dr. Hicks' sections in the Quart. Journ. of the Geol. Soc. 1877 and 1878, the junction between the two groups is not represented by a fault; but it is difficult to explain the vertical and sometimes inverted position of the lower beds of the Pebidian without the aid of such an hypothesis, and a recent inspection by the writer confirms this view. But this is only a minor point. In any case, the Dimetian ridge is on the type of the Shropshire and Malvern chains.

The same peculiarity has been noticed in North Wales. Professor T. M'Kenny Hughes, in describing certain Precambrian rocks near Bangor, observes that "the bedding is generally in an easterly direction, sometimes a little S., sometimes a little N. of E., but always oblique to or across the trend of the hills." No information is given on the influence of faults in determining the structure of these ridges.

In summing up these facts, it has been shown that, in the three cases examined by the writer, the trend of the elevations has been determined by parallel faulting; in the other example, the influence of faults has not been ascertained; in all four, the strike of the beds is transverse to the strike of the ridge.

On the hypothesis of parallel faulting, it is not difficult to suggest a reason why these transverse strikes should be found only in Precambrian mountains. In every observed case in Britain, there is a great interval between the newest Precambrian and the oldest Cambrian. The marked discordance of strike is one proof of this. An equally emphatic evidence is seen in lithological characters. The Precambrian rocks are everywhere intensely altered, and the alteration in many instances took place before the Cambrian epoch. But the overlying Cambrian strata are frequently as unaltered as ordinary Tertiary beds. It is highly probable that the fragments of Precambrian land which jut up here and there through newer formations represent a succession of epochs perhaps as long as from the Cambrian to the present day. Palæontological facts point in the same direction. The gap between the simple Protozoan of the Laurentian and the highly organized Trilobites of the Lower Cambrian is perhaps as wide as the hiatus which stretches between the Trilobite and the Mammal.

It follows from this that Precambrian formations have been sliced up by faults much more frequently than younger deposits. It is not necessary to assume, though the assumption would not be rash, that faults were more frequent in Precambrian times than they are at the present day; but it is evident that the Precambrian crust was traversed by Precambrian faults in addition to those from which it has suffered in common with newer deposits.

In Precambrian times, the surface of the earth was ridged by mountains as at present, and it is fair to assume that they were formed on the normal plan. But during an immense succession of epochs, they have been partially worn down, and the chief part of the Precambrian surface has been buried beneath great accumulations; which, in their turn, have been puckered into earth-waves which *bear no relation to the old strikes* of the crust.

Faults, as might be expected, display a tendency to run parallel with earth-waves. When the crust is being forced into sharp curves, cracks will naturally occur at right angles to the lateral pressure. Hence the faults which traverse Cambrian and Postcambrian strata, being parallel to the newer flexures, will be *transverse to the underlying Precambrian strikes.*

It is now easy to see how a pair of parallel faults traversing at the surface rocks of (say) Silurian age, and cutting down through Cambrian and Precambrian strata, will account for the origin of Precambrian ridges with transverse strikes. The upheaval of the isolated wedge, and the denudation of the overlying Cambrian and Silurian beds, require no explanation. The continued prominence of the ancient ridge would be secured by the superior induration of its metamorphic or altered volcanic constituents.

To distinguish mountains of this type from anticlinal and synclinal ridges, the term *plagioclinal*[1] is suggested.

This peculiarity of structure may prove to be of practical aid in detecting Precambrian formations. A plagioclinal axis is not necessarily Precambrian, but its transverse strike should suggest inquiry.

The facts here announced militate against an extreme school of geologists, who deny that faults have had any perceptible share in shaping the landscape. They have certainly very largely contributed to determine the scenery of South Shropshire. That the original surface produced by great dislocations has been modified by subsequent denudation does not materially affect the question. It would be equally just to argue that, because the Romance words in the English language have been modified by time, the Norman Conquest has not affected our modern tongue.

NOTICES OF MEMOIRS.

I.—The Tufo and Tripoli of the Sulphur Zone of Sicily.[2]

TWO years ago Sig. E. Stöhr, when placing the sulphur deposits in the Messinian II. of C. Mayer, and the "tufo" in the Messinian I., remarked that perhaps this last should be removed lower down, and in the December number of the Bolletino R. Com. Geol. d'Italia he says, that the discovery of fossiliferous beds in a sulphur mine, near Grotte, in the Province of Girgenti, has confirmed this opinion.

Immediately below the sulphur beds is a bituminous schist, then the tuff and tripoli, and in this "tufo," which is described as an almost plastic clay, are a great number of Foraminifera, the subject of Sig. Stöhr's paper. Of the 115 species found, 23 are new, and are mostly described and figured by Dr. Schwager in an appendix.

[1] From πλάγιος, *oblique*, and κλίνω, *to incline.*

[2] Sulla posizione geologica del tufo e del tripoli nella zona solfifera, per E. Stöhr. Boll. R. Comit. Geol. d'Italia, vol. ix. No. 11-12, 1878.

Of the remainder, the absence of *Milliolidea* (of *Spiroculina tenuis* one example was found), *Amphistegina*, *Heterostegina*, and *Polystomella* is noticeable, while the quantity of *Rhabdoidea* (38 species), *Cristellaroidea* (14), *Globigerinidea* (17), not only in the number of species, but also of individuals, is striking, and a deep sea is indicated, and is confirmed by the Radiolarian fauna, though the *Radiolaria* are only found scattered in the clay. Of the Foraminifera 63 are found at Baden, near Vienna; 38 are known living; and 52 are supposed to be extinct. The Molluscan fauna is also very similar to that of the Baden beds.

The tripoli beds, which are below the "tufo," were evidently deposited in a still deeper sea, as shown by the rich Radiolarian fauna of 109 species, studied by Mr. Stöhr. It most nearly resembles the tripoli of Caltanisetta, from which Ehrenberg described 31 species; but the Grotte beds furnish 68 new species, which will shortly be figured and described, and of the rest 29 are known living, about half of these in the Mediterranean. Some families and genera, hitherto unknown in the fossil state, are now described; for instance, the genus *Euchitonia*, which was previously only known as recent, furnishes several species, some identical with those found in the sea near Messina. The author says that this genus is sometimes so abundantly represented at Grotte that we might almost call this tripoli a mass of *Euchitonia*.

The conclusions arrived at are that both tripoli and "tufo" belong to the Tortonian (Miocene), and were deposited in deep water; afterwards there was elevation of the land, and lacustrine conditions supervened, when the deposits which now yield the sulphur were formed, during the Messinian I. II. and probably III. (of Mayer), after which sinking of the land and marine conditions followed.

A. W. W.

II.—On Some Points in Lithology. By Prof. J. D. Dana.

Under the above title Prof. Dana has recently published[1] a suggestive paper, which will be perused with much interest by those engaged in the study of rocks, and may possibly call forth a few remarks or further observations on some points discussed in the paper[2]; the object of the author being to consider the value of some of the distinctive characters which are generally accepted at the present time in defining certain kinds of rocks. As some of our readers interested in petrology may not have ready access to the original communication, we have reproduced the summary, by Prof. Dana, of the principal points with regard to rocks which have been brought out in this paper, together with his proposed classification of the crystalline rocks.

"1. The necessities of the science of Geology constitute the most prominent motive for distinguishing *kinds* of rocks; and they should determine to a large extent upon what characters distinctions should be based.

[1] Amer. Journ. of Science and Arts, vol. xvi. Nov.-Dec. 1878.

[2] See Article in the present Number, by Prof. Bonney, M.A., F.R.S., *ante*, p. 199.

"2. In determining the rocks to be grouped as one in *kind* under a common name, near identity in the chemical and mineral composition of the chief constituents is the main point to be considered; not near identity in their crystalline forms, for isomorphism presupposes diversity of composition.

"3. Distinction of *kind* should be based on difference in chemical and mineral constitution as regards the chief constituents. When such difference exists, rocks are different in *kind*, and need, for the purposes of geology, distinct names. If it does not exist, the distinction is only that of *variety;* unless (as in the case of trachyte and felsyte), the very wide extension of the rock under persistent characters makes a distinction of name important to geology.

"4. It follows from the preceding, that differences in texture: as coarse, or fine, or aphanitic; porphyritic, or non-porphyritic; stoney throughout, or having unindividualized portions among the stoney grains; and differences in microscopic inclusions; are no basis for a distinction of *kind* among rocks, but only of *variety;* and that *porphyritic structure* is of hardly more consequence than coarse or fine granular.

"5. No marked change in the constituents of the earth's erupted material occurred after the close of the Cretaceous period, or just before the commencement of the Tertiary era; and, hence, no ground exists for the distinction of 'older' and 'younger' among eruptive rocks. The 'younger' eruptive rocks are essentially like the 'older' in chemical composition and their chief mineral constituents; and they differ when at all only in texture and some other points of as little importance—qualities that distinguish merely varieties, and which have proceeded from greater prevalence in these later times of subaerial eruptions.

"6. Since 'plagioclase' is not the name of a mineral species,—several minerals, of widely different compositions, being embraced under it—it is a confounding of differences and resemblances to speak of it as a constituent of a rock. And since it now includes, through the defining of the feldspar microcline, a large part of potash feldspar, which had been supposed to be orthoclase, it has become almost synonymous with the term feldspar. The 'simplicity' its adoption has been supposed to give to lithological system would be greater if 'feldspar' were substituted, and with its present range of constitution, the evil would be hardly less.

"7. Rocks differing mineralogically, and not chemically, like related hornblendic and augitic rocks (the minerals hornblende and augite being dimorphous), are rightly made distinct rocks, since the difference has depended, to a large extent, on wide-reaching geological operations or conditions, and is, therefore, of great geological significance.

"8. Since quartz is the most widely distributed and therefore the least distinctive of the minerals of rocks, it may rightly be regarded as of subordinate importance in the distinguishing of rocks, and hence not only such names as *dioryte* and *quartz-dioryte, trachyte* and *quartz-trachyte*, etc., are acceptable, but also *syenyte* and *quartz-syenyte.*

"9. Biotite being closely like muscovite in composition, and not less common than it in granites, gneisses and mica schists, and being, moreover, unlike the mineral hornblende in chemical constitution and formula, the rocks in which biotite is a chief constituent cannot rightly be put in the same group with hornblende rocks; or those in which hornblende is a chief constituent in a group of mica-bearing rocks. Consequently the name 'mica-dioryte,' for a rock containing no hornblende, and the name 'hornblende-granite' for a rock containing no mica but hornblende instead, imply alike false relations.

"The discussion suggests the following additional remark:

"The incapabilities of the microscope and polariscope have favoured the use of the term 'plagioclase,' and have led some investigators to overlook or slight distinctions in chemical constitution. Lithology is to receive hereafter its greatest advances through chemical analyses; for chemistry alone can clear away the doubts the microscope leaves, and so give that completeness to the Science of Rocks which geology requires for right and comprehensive conclusions.

"Moreover the researches made in the laboratory to be of real geological value should be, if possible, supplemented by investigations in the field as to transitions among the rocks, and as to other kinds of relations. This field-work has often been well done, but not so by all lithological investigators.

"The principles presented lead to the following subdivisions in an arrangement of crystalline rocks, exclusive of the Calcareous and Quartzose kinds. Since leucite is a potash-alumina silicate, like orthoclase and microcline (it affording twenty per cent. or more of potash), it is here referred to the same group with the potash feldspars; and nephelite, sodalite, and the saussurites being eminently soda-bearing species, they are included with the soda-lime feldspars (anorthite to albite). This reference for lithological purposes of these minerals is sustained by their resemblance to the feldspars in constituents, and also in the quantivalent ratios between the alkalies, alumina and silica, this ratio being in leucite 1 : 3 : 8, as in andesite, and in sodalite and nephelite 1 : 3 : 4, as in anorthite. The term *potash feldspar*, as used in the headings below, is hence to be understood as covering orthoclase, microcline and leucite; and *soda-lime feldspar*, as including the triclinic feldspars from anorthite to albite, and also nephelite, sodalite and the saussurites.

"The arrangement is as follows. In the first series, the rocks graduate into kinds which are all feldspar, and into others that are all mica; and yet the amount of potash present is approximately the same.

I. The Mica and Potash Feldspar Series: including Granite, Granulyte, Gneiss, Protogine, Mica schist, etc., Felsyte, Trachyte, etc., and the Leucite rock of Wyoming.

II. The Mica and Soda-Lime Feldspar Series: including Kersantite, Kinzigite; and the nephelitic kinds Miascyte, Ditroyte, Phonolite, etc. (These nephelitic kinds belong almost as well in the preceding series.)

III. The Hornblende and Potash Feldspar Series: including Syenyte (with Quartz-syenyte), Syenyte-gneiss, Hornblende schist, Amphibolyte, Unakyte (this last containing epidote in place of hornblende); and the nephelitic species Zircon-Syenyte, Foyayte.

IV. The Hornblende and Soda-Lime Feldspar Series: including Dioryte (with Propylyte), Andesyte, Labradioryte (or Labrador-dioryte), etc., and the saussurite rock, Euphotide.

V. The Pyroxene and Potash Feldspar Series: including Amphigenyte.

VI. The Pyroxene and Soda-Lime Feldspar Series: including Augite-Andesyte, Noryte (Hypersthenyte and Gabbro in part), Hypersthenyte (containing true hypersthene), Doleryte (comprising Basalt and Diabase), Nephelinyte, etc.

VII. Pyroxene, Garnet, Epidote and Chrysolyte Rocks, containing little or no Feldspar: including Pyroxenyte, Lherzolyte, Garnetyte (Garnet rock), Eclogyte, Epidosyte, Chrysolyte or Dunyte (Chrysolite rock), etc.

VIII. Hydrous Magnesian and Aluminous Rocks, containing little or no Feldspar: including Chlorite schist, Talcose schist, Serpentine, Ophiolyte, Pyrophyllite schist, etc."

III.—A New Order of Extinct Reptiles.

PROF. O. C. MARSH has recently described[1] a genus of reptiles from the Jurassic formation of the Rocky Mountains, which he considers to represent a new extinct order—the *Sauranodonta.* The genus *Sauranodon* is closely related to *Ichthyosaurus*, and presents, in most of its skeleton, the characteristics of that genus, but is *without teeth.* The vertebræ, ribs, and other portions of the skeleton preserved cannot be distinguished from the corresponding parts of *Ichthyosaurus*, and many features of the skull show a strong resemblance. The great development of the premaxillaries, the reduced maxillaries, the huge orbit defended by a ring of bony plates, are all present, but the jaws appear entirely edentulous, and destitute even of a dentary groove. This genus *Sauranodon,* from the absence of teeth, bears a similar relation to the Ichthyosaurs that *Pteranodon* does to the true Pterodactyls, and it is interesting to find the two highly specialized forms preserved in the same region.

J. M.

REVIEWS.

I.—Der Obere Jura der Umgegend von Hannover eine Palæontologisch-geognostisch-Statische Darstellung, von C. Struckmann. (Hans'sche Buchhandlung, Hannover, 1878.)

WHILST the English Oolitic rocks are remarkable for the number of their beds and the organic richness of their contents in the Lower and Upper Middle divisions of the series, the Oxford-clay, Kimmeridge-clay, and Portland beds have not yet afforded corresponding results to the palæontologist, and the student of Jurassic Geology has therefore to turn his investigations into other regions in order to obtain an insight into the condition of the shore life of Oxfordian, Kimmeridgian, and Portlandian strata.

We therefore welcome the appearance of Herr. Struckmann's beautiful Monograph on the Upper Jura of Hanover, and recommend its careful study to all students of Jurassic Geology. The formations described in this work are the Oxford; Coralline Oolite,

[1] American Journal of Science and Arts, vol. xvii. p. 85, January, 1879.

Lower, Middle, and Upper Kimmeridge; the Under, and Upper Portland; and Purbeck beds.

The author gives first a short clear résumé of the Geological relations of each of the formations of the Upper Jura, and the palæontology of each of the groups into which he has subdivided them. The Coralline Oolite and the Kimmeridge exhibit a richness in forms of life very different from anything these formations present in our English rocks of the same age.

The catalogue of the fossils out of the Upper Jura beds is very instructive. The author has arranged the remains, consisting of 404 species, in a well-constructed table, which shows at a glance the name of the fossil, the literature of the species, its distribution in the different beds, and the locality in which it has been found. This section of the work has been most carefully executed, and conveys a large amount of information in a small compass.

In the critical remarks upon the species enumerated in the catalogue, the author appears to have exercised considerable discrimination, and has pointed out his reasons for differing with many of the determinations. He has added several new species, and given beautiful figures of them in the eight plates which accompany the work.

The concluding section is devoted to a review of the correlations of the Upper Jura of Hanover, to beds of the same age in the Swabian, Swiss, and French Jura, and the substance of the author's inquiry upon this branch of the subject is embodied in a number of well-constructed tables, followed by a learned summary of the facts they disclose. T. W.

II.—Preliminary Report of the Field Work of the United States Geological and Geographical Survey of the Territories for 1878. By F. V. Hayden. (Washington, 1878.)

THIS pamphlet contains a brief summary of the field work by the Geological Survey of part of the Territories during the season of 1878, which, owing to the delay of the usual appropriation fund for the work of the Survey, was of comparatively short duration, nevertheless much additional material was obtained. Four parties were organized. To the first division was confided the primary triangulation of the area to be surveyed. To the second was entrusted the making of a detailed survey of the Yellowstone Park. This Park is, in round numbers, 3,500 square miles. Its surface is in large part level or rolling, with several groups and short ranges of mountains diversifying it. In the eastern part, extending its whole length and forming the water-shed between the Yellowstone and the Bighorn, stand the rugged volcanic peaks of the Yellowstone Range. Nearly all of the park is covered with a dense growth of magnificent pine timber; indeed, west of the one hundredth meridian, there is no area so densely timbered with the exception of Washington Territory. The mean elevation of the park above sea-level is between 7,000 and 8,000 feet, which implies too cold a climate to admit of agriculture, save in certain very limited localities. Except along the northern border, grazing land exists only in small patches of a few acres each. There are not, so far as is known, any mines or mineral deposits within the park. The greater portion of the park was found to be covered with somewhat uniform flows of the ordinary volcanic rocks. Features of more than ordinary geologic interest occur, however, along the northern border of the park district. Here a small belt, not more than 15 by 30 miles in extent, contains a fair epitome of the geology of the Rocky Mountain region. The whole series of formations from the earliest to the most recent are almost typically developed. The only marked irregularity in the succession of geologic events occurred during the great mountain-building period of the Middle Tertiary. After that followed a number of inferior oscillations of the surface, during which an extensive series of recent Tertiary and volcanic rocks were deposited. Connecting this period with the present are the deposits of a number of great lakes, which at the present time have their chief representatives in the Yellowstone Lake.

The third party surveyed the Wind River Mountains, the Wyoming and Gros Ventres ranges, and a large area of the Snake River Valley.

Dr. Hayden accompanied the fourth or photographic division, and the route pursued gave him an opportunity to secure a very accurate general knowledge of the geological structure of a large area. The Wind River Range proved one of remarkable interest. It has a trend about north-west and south-east, with a length of about 100 miles. On the west side all the sedimentary belts have been swept away, down to the Archæan, older than the Wahsatch, and the latter formation rests on the Archæan rocks all along the base of the range, seldom inclining more than 5° to 10°. On the east side of the range the seams of sedimentary formations usually known to occur in the north-west are exposed from the Potsdam Sandstone, which rests upon the Archæan rocks, to the Cretaceous inclusive.

Along the north-western portion of the range the Wahsatch Group only is seen for some distance, but as we proceed down the Wind River Valley the formations appear one after the other, until at the lower end the entire series is exposed. The Wind River Range may be regarded as originally a vast anticlinal, of which one side has been entirely denuded of its sedimentary series, except the Middle Tertiary. On the same side of the range the morainal deposits and glaciated rocks are shown on a scale such as we have not known in any other portion of the West. Three genuine glaciers were discovered on the east base of Wind River and Frémont Peaks, the first known to exist east of the Pacific coast.

The morainal deposits are also found on a grand scale in the Snake River Valley, on the east side of the Teton Range. The numerous lakes have been the beds of glaciers, and the shores of the lakes are walled with morainal ridges. North of the Teton Mountains the prevailing rocks are of modern volcanic origin, and in the Yellowstone Park the hot springs and geysers are the later manifestations of the intense volcanic activity that once existed.

Already has Dr. Hayden conferred a great boon on geologists by the results (published by the Department of the Interior) obtained by his colleagues and himself during their explorations for some years past of the Western Territories, one portion of which was examined and described by Dr. Hayden eighteen years ago.

The publications of the Survey during the last year have been both numerous and important, including the magnificent Atlas of Colorado, in twenty sheets (noticed in GEOL. MAG. Dec. II. Vol. V. 1878, p. 365).

The tenth annual report of 300 closely-printed pages, with 80 maps, plates and sections, will soon be followed by the eleventh, a portion of which is already printed, and this again by the twelfth, for which the materials are ample and of great interest, embodying the full details of which the present pamphlet is only a preliminary report.

It is to be hoped that no unforeseen circumstances will prevent the progress of the survey of this remarkable country, which even at present has been so graphically laid before us by Dr. Hayden, and that the liberal aid of the United States Government will be continued towards the final completion of the work so ably begun and so energetically carried out,—a work, the value of which, whilst it is of such national importance, is also fully appreciated by European geologists. J. M.

III.—THE STUDY OF ROCKS. An Elementary Text Book of Petrology. By FRANK RUTLEY, F.G.S. 8vo. pp. 319. (London: Longmans & Co., 1879.)

BY the publication of this handy little volume, the author has supplied the want that has for some time been felt by all geologists, whether learners or workers, of a text-book comprising within a moderate compass the more essential information concerning the minuter phenomena of structure and association of minerals in rock masses, which it is now customary to distinguish as petrology or lithology, and which the student has had up to the present time to gather, often with considerable labour, from the voluminous pages of Zirkel, Rosenbusch, and other Continental writers. Although the greater part of the work is devoted to the description of microscopic structure in minerals, the practical details of preparation of thin sections and other methods of manipulation, the larger aspects of the subject are not neglected; the first forty pages being devoted to a brief but clear description of the phenomena observed on the large scale in the field—including well-illustrated definitions of the terms employed in geological surveying; the methods of representing formations upon maps; the rules to be observed in collecting specimens, and smaller details of outdoor work. The art of making thin sections of rocks is very completely described, several new points, the results of the author's experience, being given for the first time. The descriptions of individual minerals, and the manner in which they group into rocks, are given in sufficient detail for all the practical purposes required by the geologist. The forms assumed by skew sections of crystals, and the relation of the cleavages to the faces in crystals of hornblende, augite, and the allied species, being represented in large-sized diagrams.

The manner in which the constituent minerals of rocks vary in deviations from the normal type is indicated in tables, and by a graphic method of considerable ingenuity. The weakest point of the book is in its chemistry, which is somewhat unsystematic, though such want of system may fairly represent the state of mind of many mineralogists trained in the older systems of notation, and hesitating between the many new ones. It would be well in this respect, for the sake of uniformity, if geologists were to agree to adopt the same standard system, preferably that of the new edition of Rammelsberg's Mineralchemie. An example of eccentric etymology, on p. 101, *millemeter,* is calculated to add new horrors to the metrical system, and we trust that ere long the author may have an opportunity of correcting it in a second edition.

We had intended to go into more detail in our notice of this very sterling work; but as the price is exceedingly low, we think it better to recommend our readers to become possessed of it, and study it carefully for themselves. H. B.

IV.—An American Geological Railway Guide, giving the Geological Formation at every Railway Station, with Notes on the Interesting Places on the Routes, etc. By James Macfarlane, Ph.D. (New York: D. Appleton & Co., 1879.)

Dr. MACFARLANE is already known to the readers of this Magazine, by his work "The Coal Regions of America" (see Geol. Mag. 1874, Decade II. Vol. I. p. 37). Further anxious to render himself useful, he has published the above Geologists' Railway Guide, which is both novel and instructive. The object of the author has been to place in the hands of the traveller a series of geological time tables indicating the formations which can be observed at the principal stations on the railways at present constructed throughout the States. Prefixed to each State is a list of the geological formations occurring in it, and which subject is further expanded by about fifty pages of prefatory matter, containing a general description of the various geological formations of North America, with tables showing their succession, and a geological sketch-map of the United States. There are also foot-notes directing attention to interesting geological places and objects on the routes of the railroads.

Independently of his own geological knowledge and travelled experience, Dr. Macfarlane has been considerably assisted in the work by those geologists conversant with the different districts or states which he has not personally visited. This assistance has materially enhanced the value of the guide; and, while it is specially intended for the use of American travellers, yet the prefatory matter above referred to will afford much useful information to the reader on this side of the Atlantic who wishes to become acquainted with the general geological features of the different districts traversed by railways in the United States and Canada, so clearly and concisely put before him. J. M.

V.—Practical Geology. By W. Jerome Harrison, F.G.S., etc. Small 8vo., pp. 157. (London, Stewart & Co., 1878.)

THIS is a very clearly expressed and accurate guide to the main features of British geology, written with the object of tempting junior students to learn the science as much as possible out of doors. Descriptions of geological apparatus, and accounts of all the principal formations, are given, with which are interspersed many notes in explanation of phenomena to be observed.

REPORTS AND PROCEEDINGS.

The Geologists' Association.

AT a Meeting held at University College, on the 7th March last, Mr. H. Goss, F.L.S., F.G.S., etc., communicated a paper on "The Insect Fauna of the Primary or Palæozoic Period, and the British and Foreign Strata of that Period in which Insect-remains have been detected."

After making some introductory observations, and alluding to the rarity of fossil insects in the Palæozoic rocks of the United Kingdom, the author stated that on the Continents of Europe and America fossils of this class had been met with more frequently, especially in the Coal-measures, and that a few had also been obtained from the Permian rocks of Saxony, and from the Devonian rocks of New Brunswick, North America.

The author then alluded to those geologists and zoologists who had determined and described fossil insects from Palæozoic rocks. calling special attention to the writings and investigations of Dr. Henry Woodward, F.R.S., in England; of Prof. Goldenberg, Prof. Germar, Dr. Giebel, Prof. Oswald Heer, Dr. Dohrn, Herr Eugen Geinitz, Dr. Geinitz, Prof. Van Beneden, M. Preudhomme de Borre, M. Ch. Brongniart, and M. Coemans, on the Continent of Europe; and of Mr. S. H. Scudder, Dr. Dawson, Prof. Dana, Prof. Leo Lesquereux, Mr. C. F. Hartt, and others, in America.

The few fossil insects discovered in the British Coal-measures were then enumerated; they included a beetle and a locust from Coalbrook Dale, three *Orthoptera*, described by Mr. Kirkby, from the neighbourhood of Sunderland, and one insect of that order from the Scotch Coal-measures, which had been described and named by Dr. Henry Woodward.

The Permian strata of Continental Europe, in which fossil insects had been detected, were next noticed, and attention was called to a remarkable fossil insect obtained from the neighbourhood of Birkenfeld, which belonged to an extinct order, and combined some of the characteristics of the *Neuroptera* and *Hemiptera*, and was supposed by Dr. Dohrn to have been descended from a common ancestor of both those orders.

About 12 other species from the Permian of Saxony, including 2 *Hemiptera*, and 9 *Orthoptera* (*Blattidæ*), were then enumerated.

The Coal-measures at Wettin and Lobejün, in Westphalia, and at Saarbrück, near Trêves, were then referred to; from these Coal-fields a considerable number of insects had been discovered, the majority of which had been referred by Prof. Germar and Dr. Goldenberg to the orders *Orthoptera* and *Neuroptera*, and a few to an extinct order, which had been named by Dr. Goldenberg *Palæodictyoptera*. A number of other insects from Loebjün, Mannebach, Erbignon, Valais (Switzerland), Saarbrück, and elsewhere, which had been described by Prof. Heer, Dr. Goldenberg, Dr. Dohrn, Herr E. Geinitz and others, were then alluded to. One insect (*Blattina Helvetica*), from Erbignon, was of especial interest as being, according to Dr. Heer, the oldest Swiss fossil animal known.

Amongst the most interesting of the fossil insects obtained from the Belgian Coal-fields was one described by Prof. Van Beneden and M. Coemans, and which had recently been referred by Dr. Goldenberg to the extinct order (*Palæodictyoptera*) before mentioned.

Another specimen from the same Coal-fields had been referred by Dr. Breyer and M. Preudhomme de Borre to the *Lepidoptera*. This supposed butterfly had been recently examined by Mr. R. M'Lachlan, F.R.S., who had decided that the fossil was that of a *Neuropterous* insect belonging to the *Ephemerina*, and a note of his opinion to this effect had been read in August, 1877, by the Baron de Selys-Longchamps, before the Entomological Society of Belgium.

The various localities in the Coal-fields of North America in which insects had been found were then enumerated.

It appeared that all the insects discovered in the American Coal-measures were either *Orthoptera* or *Neuroptera*, though some three or four of the latter order had lately been referred by Dr. Goldenberg to the extinct order before mentioned.

The six oldest fossil insects in the world had been obtained by Mr. C. F. Hartt, in rocks of Devonian age, in the neighbourhood of St. Johns, New Brunswick. They were all representatives of the order *Neuroptera*; though most of them were synthetic, combining characteristics of two or more families or groups.

The author stated that altogether about 113 species of fossil insects obtained from Palæozoic rocks had been named and described, 5 of which were from the United Kingdom, 80 from the Continent of Europe, and 28 from America; and that they included 3 species of *Coleoptera*, 3 *Hemiptera*, 66 *Orthoptera*, 27 *Neuroptera*, and 14 of the extinct order *Palæodictyoptera*. These fossils were geologically distributed as follows, viz. 13 from the Permian, 94 from the Carboniferous, and 6 from the Devonian.

The author then proceeded to summarize the facts which he had brought under notice in this and his two preceding papers on the subject. After quoting Prof. Häckel, Dr. Fritz Müller, Sir John Lubbock and others, as to the supposed origin of insects, and remarking on the vast antiquity of many of the family types of this class of the animal kingdom, and calling attention to the fact that the fossil species, even from the very oldest rocks, had, with very few exceptions, been referred to existing orders, the author observed that it was evident that the geological record was not nearly old enough or perfect enough to afford much direct evidence in support of the theory of the evolution of the existing orders of insects from inferior organisms. The best evidence afforded by Palæontology in support of this theory seemed to him to be, that some of the species from the older rocks were synthetic, combining essential characters of two or more orders, and that it was probable, therefore, that if insects should be detected in still older rocks, they might be found to depart still further from existing types.

Attention was then called to the antiquity of many of the existing genera, and the very small amount of change, as compared with that of some other classes of the animal kingdom, which had taken place in many of them during the geological record.

Mr. Goss then referred to the dates of the apparition of the various orders of insects on the geological horizon. It appeared that the extinct order *Palæodictyoptera* and the *Neuroptera* were the oldest orders; that they were followed by the *Orthoptera*, and that those orders included, with three or four exceptions, all the *Insecta* of the Palæozoic period, towards the close of which the *Coleoptera* and *Hemiptera* appeared. Early in the Mesozoic period the two last-named orders began to be abundant and widely distributed, and somewhat later were followed by the *Diptera* and certain families of the *Hymenoptera*, and that towards the close of this period other families of the *Hymenoptera*, including the bees, appeared; and about the same time, or early in the Tertiary age, succeeded the *Lepidoptera*.

Attention was then called to the important deductions which might be drawn from a study of fossil insects, as to the probable state of the vegetation prevailing during the period of their existence. The author also observed that a comparison of European fossil species with those now existing in Europe, furnished satisfactory evidence of the fact that the temperature of the Continent had undergone many changes, and that the size of the species, the distribution of genera, and the numerical relations existing between various groups indicated the former prevalence of warmer climates than those now existing in the same latitudes.

Geological Society of London.—I.—March 12, 1879.—Henry Clifton Sorby, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "On Perlitic and Spherulitic Structures in the Lavas of the Glyder Fawr, North Wales." By Frank Rutley, Esq., F.G.S.

The rock, to the eye and under the microscope, has all the appearance of a felstone, but in the latter also exhibits perlitic structure as clearly as one of the Saxony perlites. Some of the other felstones of the Glyder Fawr show numerous spherulites. These felstones have been determined by the Survey to be lavas of Bala age.

2. "The Gold-leads of Nova Scotia." By Henry S. Poole, Esq., M.A., F.G.S., Government Inspector of Mines.

The author remarked upon the peculiarity that the gold-leads of Nova Scotia are generally conformable with the beds in which they occur, whence Dr. Sterry Hunt and others have come to the conclusion that these auriferous quartz veins are interstratified with the argillaceous rocks of the district. With this view he does not agree. He classified the leads in these groups according to their relations to the containing rocks, and detailed the results of mining-experience in the district, as showing the leads to be true veins by the following characters:—1. Irregularity of planes of contact between slate and quartz; 2. The crushed state of the slate on some foot-walls; 3. Irregularity of mineral contents; 4. The termination of the leads; 5. The effects of contemporary dislocations; 6. The influence of strings and offshoots on the richness of leads. The author further treated of the relative age of the leads and granite, and combated the view that the granites are of metamorphic origin, which he stated to be disproved by a study of the lines of contact. He also noticed the effects of glaciation on the leads, and the occurrence of gold in Carboniferous conglomerate.

3. "On Conodonts from the Chazy and Cincinnati groups of the Cambro-Silurian, and from the Hamilton and Genesee-Shale divisions of the Devonian, in Canada and the United States." By G. Jennings Hinde, Esq., F.G.S.

After a sketch of the bibliography of the subject, the author described the occurrence of Conodonts. In the Chazy beds they are associated with numerous *Leperditiæ*, some Trilobites, and Gasteropods; in the Cincinnati group with various fossils; and in the Devonian strata principally with fish-remains; but there is no clue to their nature from these associated fossils. They possess the same microscopic lamellar structure as the Russian Conodonts described by Pander. The various affinities exhibited by the fossil Conodonts were discussed; and the author is of opinion that though they most resemble the teeth of Myxinoid fishes, their true zoological relationship is very uncertain. The paper concluded with a classification of the Conodonts from the above deposits.

4. "On Annelid Jaws from the Cambro-Silurian, Silurian, and Devonian Formations in Canada, and from the Lower Carboniferous in Scotland." By G. Jennings Hinde, Esq., F.G.S.

After referring to the very few recorded instances of the discovery of any portions of the organism of errant Annelids as distinct from their trails and impressions in the rocks, the author noticed the characters of the strata, principally shallow-water deposits, in which the Annelid jaws described by him are imbedded. A description was given of the principal varieties of form and of the structure of the jaws. They were classified from their resemblances to existing forms under seven genera, five of which are included in the family Eunicea, one in the family Lycoridea, and one among the Glycerea. The author enumerated fifty-five different forms, the greater proportion of which are from the Cincinnati group.

II.—March 26, 1879.—Henry Clifton Sorby, Esq., F.R.S., President, in the Chair. The following communications were read:—

1. "Results of a Systematic Survey (in 1878) of the Directions and Limits of Dispersion, Mode of Occurrence, and Relation to Drift-deposits of the Erratic Blocks or Boulders of the West of England and East of Wales, including a Revision of many years' previous Observations." By D. Mackintosh, Esq., F.G.S.

The author's researches lead him to the following conclusions:—Boulders from the North-Criffell range and Lake-district can be traced from the Solway Firth to near Bromsgrove (about 200 miles), and over an area in greatest breadth (from near Macclesfield to Beaumaris) of 90 miles, those from Criffell being particularly abundant near Wolverhampton. Boulders from the Arenig occupy a triangular area, limited by a line drawn northward from Chirk to the Dee estuary, and to the south-east of that town are found as far as Birmingham and Bromsgrove. The dispersion of the more distant Criffell Boulders would require submergences of from 400 to 1400 feet; of the Lake-district a little deeper; while the distant dispersion of the Arenig Boulders took place at submergences between 800 and 2000 feet. The author describes several of the more local drifts, and correlates the Lower Boulder-clay of the North-west with the Chalky Boulder-clay of the East of England. He considers floating-ice, not land-ice, to have been the agent of dispersion.

2. "On the Glaciation of the Shetland Isles." By B. N. Peach, Esq., F.G.S., and John Horne, Esq., F.G.S.

After an account of previous opinion on the subject, the authors proceeded to describe the different islands, reviewing in succession the physical features, geological structure, the direction of glaciation, and the various superficial deposits. From an examination of the numerous striated surfaces, as well as from the distribution of Boulder-clay and the dispersal of stones in that deposit, they inferred that during the period of extreme cold Shetland must have been glaciated by the Scandinavian Mer de Glace, crossing the islands from the North Sea towards the Atlantic. In the island of Unst, blocks of serpentine and gabbro are found in the Boulder-clay on the western shores derived from the rock-masses occurring on the east side of the watershed. Moreover, on the mainland between Scalloway and Fitful Head, blocks derived from the Old Red Sandstone formation on the eastern sea-board are abundant in the Boulder-clay on the west side of the watershed. The relative distribution of these stones in the sections on the west coast is in direct proportion to the relative areas occupied by the rocks on the east side of the watershed. It was likewise pointed out that after the period of general glaciation Shetland nourished a series of local glaciers, which radiated from the high grounds, the direction of the striæ being at variance with the older system, while the morainic deposits also differ in character from the Boulder-clay produced by the great Mer de Glace. The authors described the order of succession in the Old Red Sandstone formation in Shetland, and referred to the discovery of an abundant series of plant-remains in rocks which have hitherto been regarded as forming part of the series of ancient crystalline rocks. The plant-remains are identical with those found in the Old Red Sandstone rocks in Caithness, Orkney, and Shetland, from which it was inferred that the quartzites and shales in which the fossils are imbedded must be classed with this formation. The authors also described the great series of contemporaneous and intrusive igneous rocks of Old Red Sandstone age, adducing evidence in proof of the great denudation which has taken place in the members of this formation in Shetland.

3. "On the Southerly Extension of the Hessle Boulder-clay in Lincolnshire." By A. J. Jukes-Browne, Esq., B.A., F.G.S.

The southern boundary of the Hessle Clay has not hitherto been satisfactorily determined. The author traces this deposit along the border of the flat fen land in South Lincolnshire, near Burgh, Steeping, etc., and the east and west Fen. He concurs with Mr. Searles Wood in believing the clay to be the product of shore-ice along a coast-line, and that the materials were in great part derived from the older "Purple Clay." He differs, however, from that author as to the correlation of the Hessle series, thinking this more probably older than the oldest river-gravels of the South-east of England. In an appendix a deep well-section at Boston is discussed, and reasons are given for assigning the greater part of the beds in this to the Jurassic Clays, not to the Glacial.

CORRESPONDENCE.

THE MAMMOTH NOT PRE-GLACIAL IN BRITAIN.[1]

Sir,—Many will regret that Prof. Dawkins has lent the authority of his name to the opinion that the Mammoth is pre-Glacial in Britain, but perhaps few may take the trouble to point out how very unsatisfactory is the evidence he brings forward (Quart. Journ. Geol. Soc., Feb. 1879). His evidence that the Mammoth is pre-Glacial in the South of England rests upon the assumption that the gravel beneath the Boulder-clay at Bricket Wood, between Watford and St. Albans, is pre-Glacial. There is no proof that it is *older* than the Lower Boulder-clay or Cromer Till of the Norfolk coast; on the contrary, it *may be newer*. And this being the case, the evidence is of no value whatever in assigning a pre-Glacial age to the animal-remains found in it.

Mr. Clement Reid pointed out in a recent number of "Nature" (vol. xix. p. 122) that there was no evidence to show that any single specimen of the *Elephas primigenius* had been obtained *in situ* from the pre-Glacial or Forest Bed series of the Cromer coast—a conclusion which only bore out the repeated statements of Mr. Gunn and others. As the subject is one of great interest, perhaps Prof. Dawkins will kindly state where are to be seen those specimens upon which he founds his opinion that the Mammoth has been found in the Forest Beds.

Horace B. Woodward.

Aylsham, Norwich.

[1] The publication of this letter has been unintentionally delayed.—Edit. Geol. Mag.

GEOLOGY OF NORTH DEVON.

Sir,—Mr. Kinahan has made a statement in his communication to you, in February, which I cannot allow to remain any longer unnoticed. At the end of his "Note in Press," p. 74, whilst attributing but little value to the fossil evidence as determining the position of the North Devon beds, he writes, "The species have been collected without that care and precision which can alone render them of use in marking horizons. The localities assigned to the specimens, in the collections chiefly relied upon, are such as Torquay, Chudleigh, etc.; where two, if not more, distinct groups of rocks are developed." Now, I must leave the South Devon geologists to defend themselves, and the care with which their collections have been made, and the localities properly assigned; they have plenty of hard work before them in their attempt to correlate these extremely puzzling beds with the Northern beds. A recent visit to Torquay strengthens my view of this; but so far as the fossil evidence affects the question of the regular sequence of the beds, from the Foreland Sandstones to the Pilton beds, I venture to think nothing can well be clearer. As to the care and precision with which the collections have been made, I boldly assert none can be greater. I need only refer to those of Mr. Townshend Hall and Mr. Valpy; and to the Catalogue of North Devon Fossils published by the former in Quart. Journ. Geol. Soc. 1867, p. 376. Mr. Hall's accuracy and knowledge of the North Devon strata will not be questioned by any one who knows him. And to Mr. Valpy's keen eye for fossils, his care in assigning the proper localities to them, and his intimate knowledge of the coast-line from the Foreland to Baggy Point, I, who have spent many a long and pleasant day with him, can most fully testify.

A word as to the stratigraphical position of the beds. If "Jukes's fault" has not been sufficiently disposed of by Mr. Etheridge, I invite my friend Mr. Kinahan to attend the approaching Meeting of the Devonshire Association at Ilfracombe, where he, with his fellow-countrymen, who have looked at the Devon geology across the water from an Irish point of view, will have a hearty welcome; and I ask him to prove then to the satisfaction of the Secretary, Mr. Pengelly, the disproof of an "hypothetical" fault, which has never yet been proved. Can he do it? The coat has been trailed: let him take up the challenge. H. H. Winwood.

Bath, *March* 21*st*, 1879.

KINAHAN'S GEOLOGY OF IRELAND.

Sir,—In Mr. Kinahan's Manual of the Geology of Ireland (p. 315), I find a reference to Mr. Jukes' explanation of the formation of the valleys in S.W. Ireland, accompanied by the following footnote: "Jukes at the time considered that the Cork rocks were once covered by the Carboniferous Limestone of the central plain. Subsequently he had to allow that this was incorrect, and his theory formed on the supposed Limestone hills therefore falls to the ground, although it is still quoted."

In Mr. Kinahan's former book, "Valleys and their Relations to Fissures, etc.," the following passage occurs: "The first of these propositions [that limestone once existed over the whole of S.W. Ireland] Mr. Jukes subsequently gave up. . . . This, however, does not much affect the present subject [*i.e.* formation of river-valleys], as some of the other rocks are nearly as easily denuded as limestone."

I should feel obliged to Mr. Kinahan if he would explain the full meaning of the extraordinary statement contained in the first of the above quotations, and also how the latter passage is to be reconciled with the former.

I entirely fail to see how Mr. Jukes' theory depends on the supposition that the Carboniferous Limestone once extended over the South-west of Ireland, and if Mr. Kinahan will carefully re-read the original paper in the Quart. Journ. Geol. Soc., vol. xviii., I think he will see that he has been under a misapprehension regarding the "supposed Limestone hills." There is only one passage in which such hills are supposed, and this forms part of a hypothesis mentioned only to be presently dismissed as leading to utter absurdity and confusion. The dominant ridges really involved in Jukes' explanation are the great anticlinals of so-called Old Red Sandstone separating the synclinal valleys in Cork and Waterford; he supposes the streams to have commenced the erosion of their channels along the surface of a plain of marine denudation which sloped southwards from these dominant ridges.

I am aware that Mr. Kinahan has published his idea of the origin of these and other valleys, and I have no desire to enter into a discussion regarding his peculiar views; but I must protest against so summary a dismissal of Jukes' well-considered theory. I need only add that I am one of those who believe that it completely explains the courses of many river-valleys both in England and Ireland.

Highgate, *March* 10. A. J. Jukes-Browne.

PROF. HULL AND G. H. KINAHAN.

Sir,—The statements of Prof. Hull in the Geological Magazine for March, 1879, being mostly personal, I cannot think my answering them would be any advantage to Science. My facts cannot be disproved, and any one interested in the question can judge which is right by examining the Irish rocks for themselves. As to the supposed Permian, if Prof. Hull is mistaken, I am not bound blindly to follow him; and my opinion as to the age of the rocks is backed by the opinions of Griffith and others, also by the fossils found in the rocks. G. Henry Kinahan.

Geological Survey of Ireland.

OCCURRENCE OF *EURYNOTUS* IN THE CARBONIFEROUS LIMESTONE OF BELGIUM.

Sir,—Prof. de Koninck has, in the recently published first part of his new great work on the "Faune du calcaire Carbonifère de la Belgique," p. 25, plate iii., described, under the name of *Platysomus* (?) *insignis*, De Kon., a fish from the Carboniferous Limestone of Viesville, a query being appended to the genus on account of want of evidence as to dentition.

An inspection of the figures by which Prof. de Koninck's description is illustrated at once convinced me that not only was the query justifiable, but that the fish in question could not possibly belong to the genus *Platysomus*, the scales being represented as strongly denticulated on their hinder margins, besides being more obliquely arranged and differing essentially both in sculpture, and in the position of their articular spines, from those characteristic of the above-named genus.

I accordingly wrote to Prof. de Koninck, expressing these convictions, as well as my desire to see the specimens; whereupon my distinguished friend, with great kindness and courtesy, at once communicated my wish to the authorities of the Royal Museum of Natural History in Brussels, to whom I am much indebted for the opportunity of examining one of the specimens referred to.

As I had suspected, I find that it belongs to the genus *Eurynotus*, and to a species closely allied to, if not identical with, the well-known *Eurynotus crenatus*, of the Scottish Lower Carboniferous rocks. This genus has hitherto been found only in Scotland (Agassiz's "*Eurynotus*" *tenuiceps*, from the American Triassic rocks, having turned out to be an *Ischypterus*), and the Viesville specimens are therefore the first veritable examples of *Eurynotus* which have been discovered elsewhere. In geological range, it remains, however, still confined to the Lower division of the Carboniferous formation, not a scale of *Eurynotus* having been as yet found above the horizon of the Millstone Grit. R. H. Traquair.

Edinburgh, 14*th April*, 1879.

THE BRIDLINGTON AND SEWERBY GRAVELS.

Sir,—The gravels overlying the Purple Boulder-clay at Bridlington Quay have been generally considered as decidedly Post-glacial, if not quite recent.

I cannot now enter into a full discussion of the age of all these gravels; but a careful examination of the cliff has convinced me of the Glacial age of a portion of them. I made some sketches of the coast section last November, which I hope some day to publish; and these will, I think, convince any one of this; but at present I must confine myself to saying this much. On the north side of the town the Purple Boulder-clay is overlaid by gravels, which are shown to be of Glacial age by their contorted bedding, and by the way in which they are jammed into and against the Boulder-clay. These crushed and crumpled gravels occur where the cliff is low, extending about as far as Sands Lane. North of this point the cliff rises at Potter Hill and continues to rise towards Sewerby; and along this part of the cliff the Boulder-clay is overlaid by gravels evenly bedded, which I call the Sewerby gravels. I shall not now discuss the question of the relation of these to the previously mentioned gravels. I will merely say that these Sewerby gravels, though as a rule evenly bedded, do exhibit in some places near their base contortions and crushings, such as bespeak ice-action, or inclose small masses of Boulder-clay in their lower layers; so that I consider it established, independently of further considerations, that these gravels at all events date back to glacial times. I have other reasons for thinking so, but content myself at present with the above. I would only add that it by no means follows, because these gravels began to be deposited before ice-action had ceased in this area, that their deposition did not continue down to Post-glacial times. In other words, while their lower part is of Glacial, their upper part may be of Post-glacial age.

South of the town is a corresponding cliff, consisting of current bedded sand and gravel, and finely laminated sandy clays (Phillips' Warp Beds). These do not show any undoubted signs of ice-action; they would seem, however, to have once been continuous with the Sewerby gravels, but to have had their continuity interrupted by the denudation of the valley by which the Gypsey Race escapes to sea.

In none of the above-mentioned beds have any shells been found as yet; this, though it proves nothing, is quite in keeping with the idea of their being of Glacial age, and is possibly due to their having been deposited in shallow seas freshened by the melting of the great ice-sheet; the current bedding, dipping now in one direction and now in the opposite, bespeaks tidal currents in shallow water, and the warp-like character of the laminated clays is equally suggestive of a tidal estuary.

I may mention that I have found fragments of marine shells in sand-beds in the interior in localities where they have not been noticed before—viz. in the remarkable series of sand-hills running south from Harpham Moor and at Brigham. These, I suspect, will turn out to belong to the set of beds described by Phillips at pages 61 and 62 of his work on the Yorkshire Coast.

It is right to add that the gravels at Bridlington mentioned above are here and there overlaid or replaced by more recent fresh-water deposits, gravels, and marls. This, of course, is well known.

Bridlington Quay. J. R. Dakyns.

GLACIAL TROUGHS BENEATH THE GLACIER DES BOSSONS.

Sir,—Glacial grooves and furrows are always described in geological works as running in the direction of the ice-flow which formed them. That this should, perhaps generally, be the case, is so obvious that it may seem superfluous to give proofs thereof; nor are such far to seek; they are these: the direction of the grooves is often found to coincide with that of glacial striæ, with that of the transport of erratics, and with the direction of motion indicated by crag and tail, and by the forms of *roches moutonnées*. Yet it is not always so. In many cases grooves and furrows, such at least as are broad and shallow, must have been formed by ice moving not *along* but *across* the direction of the grooves. This would be apt to be the case especially on steep ground, and such I would call troughs. I saw a very good instance of this in the year 1873, in the case of the Glacier des Bossons. From a point in the hill-side beyond the pavilion of the Pierre Pointue, and on the right-hand side of the Mont Blanc route, as you ascend, I got a capital view of the glacier's rocky floor, partly laid bare; and made a rough diagram of the form of the ground, which it is not necessary to reproduce. The bed of the glacier was seen to be scooped out transversely to the glacier's length. It was evident that the rocky floor beneath the ice consisted of a wave-like series of ridges and hollows running along the hill-side across the line of ice-flow. The reason of this, and the mode of formation of the hollows or troughs, was obvious. The rocks over which the ice is moving consist of a series of crystalline schists, of varying degrees of hardness, dipping into the hill at a high angle. Accordingly, as the ice descends, it will wear away the softer strata more than the harder, and thus scoop out a series of troughs along the strike of the schists. In the case of the Mont Blanc range this strike is across the glacier, and thus the latter's rocky floor gets furrowed across the direction of ice-flow.

In my sketch is represented in one spot a mass of moraine stuff caught in a deep hollow in the rocks below the ice.

Another point interesting to geologists, which I may mention, is that the lateral moraines of the Glacier des Bossons are rudely but distinctly stratified. The layers, as might be expected, dip down the valley, very much with the fall of the ice. J. R. Dakyns.

Bridlington Quay.

MIOCENE OR EOCENE? AGE OF THE BOVEY LIGNITES.

Sir,—If it be necessary to remove the Bovey beds from the Miocene to the Eocene, why not carry them back at once to the Cretaceous age?

According to Professor Morris, the Floras of the Tertiary and Cretaceous have been mistaken one for the other.[1] Dr. Duncan[2] says the mean temperature required for the growth of the Corals now found in the Haldon Greensand would be equal to 74° Fahrenheit, which must have been a climate equally favourable to the plants of the Bovey beds. In fact the *Sequoia*, a very characteristic fossil in these beds, also occurs in the Coral bed on Haldon. There would then be no need of going eighty miles for its nearest neighbour.

The Priory, Colleton Crescent, Exeter, William Vicary.
April 13, 1879.

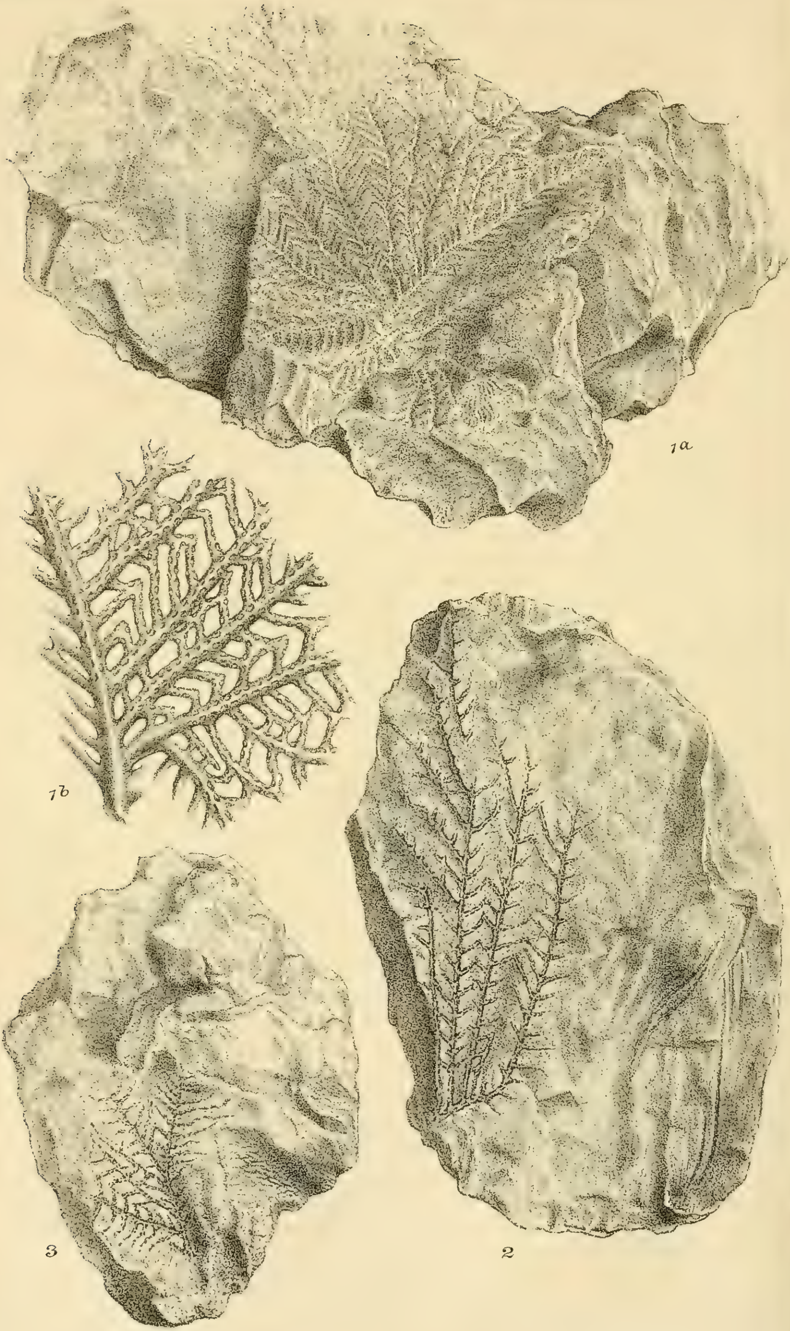
MISCELLANEOUS.

Geological Survey of the Territories.—The United States Congress has sanctioned a scheme for the reorganisation of the American Surveys. It is understood that the Geological Survey will be placed under the control of Mr. Clarence King, who has so long had charge of the Geological Exploration of the 40th Parallel; but no details have yet reached us.—*Nature*, *April* 17*th*.

OBITUARY.

We regret to record the death of James Nicol, F.R.S.E., F.G.S., late Professor of Natural History in the University of Aberdeen. He published a Guide to the Geology of Scotland; a Geological Map of Scotland; and is the author of many original contributions to its Geology.

[1] Prof. Morris, on Cretaceous Flora, vol. xv. p. 47, of Popular Science Review.
[2] Prof. Duncan, Journal Geol. Soc. Feb. 7, 1879, page 96.



A. S. Foord lith. West, Newman & Co. imp.

Ramipora Hochstetteri var. carinata, *Eth.*

Caradoc Corwen. N. Wales

THE

GEOLOGICAL MAGAZINE.

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No. VI.—JUNE, 1879.

ORIGINAL ARTICLES.

I.—On the Occurrence of the Genus *Ramipora* (Toula) in the Caradoc Beds of the Neighbourhood of Corwen.

By R. Etheridge, Junior, F.G.S.;
of the British Museum.

(PLATE VI.)

To the recently published paper by my father, "Palæontology of the Coasts of the Arctic Lands visited by the late British Expedition," etc.,[1] I contributed some notes on the Polyzoa obtained during the progress of the Expedition from the Palæozoic rocks of the regions visited. Amongst other forms I referred at some length to Dr. F. Toula's genus *Ramipora*, and pointed out its affinities to various genera of Palæozoic Polyzoa, and more particularly to *Synocladia*, King, in the following words:—"It appears to differ from the first of these" (*i.e.* from *Synocladia*) "in the absence of dichotomization of the stem and primary branches, so far as the remains of it are known to us; secondly, in the bilateral symmetry of the latter; thirdly, in the fact that the cells all open on the same plane on each side the median keel, whereas in *Synocladia* the stems and branches are divided longitudinally by several carinæ, between which the cell apertures occur. Again, in *Ramipora* both aspects of the polyzoarium are carinate, but in *Synocladia* only one. Lastly, in *Synocladia* the dissepiments all appear to be regularly celluliferous, but in *Ramipora* this does not appear to hold good to the same extent."

Mr. G. J. Williams, of Tanygrisian, Festiniog, lately brought to the British Museum some really beautiful impressions, in a grey micaceous schist, of a Polyzoon found by himself in the neighbourhood of Corwen, and which constitutes, I believe, an undescribed variety of Toula's *Ramipora Hochstetteri*. So far as I know, *Ramipora* has hitherto been met with in the Permo-Carboniferous beds of the Arctic regions only, and this extension backwards in time of a *Synocladia*-like type is a point of much interest. I am also acquainted only with one species, *R. Hochstetteri*, which the Corwen form very closely resembles, in many points of detail.

[1] Quart. Journ. Geol. Soc. 1878, vol. xxxiv. pp. 568–639.

A reference to the Plate will show that the habit of the polyzoarium is clearly that of *Ramipora*, as distinguished from *Synocladia*, a central or chief stem from which are given off a series of straight non-bifurcating branches, without any separation by longitudinal ridges or keels, beyond that occupying the centre of each stem or branch, and the cells all opening much on the same level; instead of, as in the latter, a series of continually dichotomizing branches, longitudinally divided by several carinæ separating the cells.

The polyzoarium in this interesting Polyzoon was probably openly infundibuliform, or basket-shaped, there being a series of the principal straight stems, all branching off at the base from a common root, or stolon, but in no way bifurcating or springing from one another. Four of these stems are shown in the larger specimen, each giving off laterally, and at subalternate distances, the secondary stems, which, as in the former case, in no way bifurcate or dichotomize, but proceed direct, and intact in themselves, to the periphery of the frond. Here and there however, between two of the secondary stems, similar short (or abortive?) ones arise from the main stem, which unite directly with the cross-bars or dissepiments. As in most of these frondescent Polyzoa, the common root is devoid of pores or cell-openings.

From the secondary stems are given off the interstices, or cross-bars, by the union of which are formed the mesh-openings, or what in a *Fenestella* would be called the fenestrules. These dissepiments spring from opposite sides of each secondary branch at an acute angle, and on a level with one another, and uniting more or less in the middle line between every two contiguous secondary branches, with those arising from the latter give rise to the broadly V-shaped fenestrules. As a rule, great regularity may be noticed in the form of these openings, taking the whole surface of the frond, but here and there an irregularly-formed one is to be met with. The section of the main stems, secondary branches, and dissepiments was biangular or diamond-shaped.

The angular or apical ridge of the various stems and branches of the frond is devoid of any pores, or other features of interest; but on the sides of the main stems, immediately under the apical ridge, are two linear rows of contiguous pores or cells with round apertures, those of the one row being a little subalternate with those of the other. There may be a third row, but I have not been able to distinguish it, and from the width of the lateral portions of these stems I hardly think there is room for the expansion of the cell-mouths. The description of the arrangement of the cells on the main stems will also suffice for that on the secondary stems and the interstices—for I cannot detect any difference in their distribution. The reverse face of the frond is, as before said, angular, but non-celluliferous.

So little has been done in this country towards the elucidation of Silurian Polyzoa, with the exception of the brief original descriptions, mostly by Lonsdale, and scattered through the works of Murchison,[1] that there is always the chance of re-describing or re-

[1] And those contained in Prof. M'Coy's Brit. Pal. Fossils.

naming some already known form, which may have been noticed from a mere fragment, and that imperfectly—no matter how carefully the literature of the subject is searched.

So far as my acquaintance with British Silurian Polyzoa goes, the only one which could possibly be, in fragments, confounded with that now under description is *Glauconome disticha*, Goldf. This error has been committed in specimens in the British Museum, and in the Museum of Practical Geology; but after Prof. M'Coy's clear description of *G. disticha*, an easy separation may readily be arrived at. Fragments of the latter may be at once distinguished from those of Mr. Williams' fossil, by the rounded contour of the stems and branches on the reverse face, and their granular ornamentation, whereas in the specimens now under consideration it is angular, and so far as known without granules or striæ of any kind. Again, as regards the cell-bearing face; in *G. disticha* the pores are large, oblong, thick-edged, occupying the whole width of the face on each side the central keel, and their ends in contact. In *Ramipora*, on the contrary, the apertures are round, similarly placed, without elevated edges of any kind, merely forming a series of depressions on the interstitial surface, and separated from one another by an appreciable distance.

It now only remains for us to consider how far this interesting Caradoc fossil agrees with the single species of *Ramipora* hitherto described, *R. Hochstetteri*, Toula. The arrangement of the branches, primary, secondary, and ternary, is identical in both; the cross section of the latter appears to be the same. The chief points of difference appear to lie in the greater development of the central keel of the branches, and judging from Dr. Toula's figure, a greater regularity in the disposition of the pores. Finally, taking the whole frond into consideration, the Caradoc form exhibits a tendency towards a less robust habit. Pending a more complete description of *R. Hochstetteri*, Toula, I fail to see the advisability of establishing a new species for this interesting fossil, but shall at present content myself with considering it as a variety only, under the name of *Ramipora Hochstetteri*, Toula, var. *carinata* (mihi). For those observers who prefer to look upon the points above brought forward as of specific value, the designation *carinata* will, perhaps, be acceptable in that sense.

The undoubted interest attached to this elegant fossil lies in the fact of the extension backwards in time of a form only previously known to exist towards the close of the Palæozoic period.

I am indebted to Mr. G. J. Williams for the loan of his really beautiful specimens. I have also been permitted to borrow a series contained in the Museum of Practical Geology. For the loan of Lonsdale's type specimen of *Glauconome disticha*, Goldf., contained in the Murchison Collection, I am indebted to the President and Council of the Geological Society. This assemblage of examples, with a few which unexpectedly came to light in the British Museum Collection, has enabled me to study a fine series from the Welsh Caradoc rocks.

Localities and Horizon.—"A little south of the town of Corwen," in beds of Caradoc age (*G. J. Williams*). Bwlch-y-Gasy, near Corwen, and near Cynwyd, in a micaceous clay slate of similar age (*British Museum*). South of Cefn Coch, near Llangollen, similar matrix and horizon (*Museum Practical Geology*).

EXPLANATION OF PLATE VI.

FIG. 1. *Ramipora Hochstetteri*, Toula; var. *carinata*, R. Eth., jun. Caradoc, nr. Corwen (Cabinet of Mr. G. J. Williams, Tanygrisian).
1*a*. General view, natural size.
1*b*. Portion of a frond, enlarged about twice (drawn from a plaster cast).
FIG. 2. *Ibid.* nr. Llangollen (Mus. Pract. Geology, nat. size).
FIG. 3. *Ibid.* nr. Corwen (Brit. Mus., nat. size).

II.—ON A NEW GENUS OF FAVOSITE CORAL FROM THE NIAGARA FORMATION (U. SILURIAN), MANITOULIN ISLAND, LAKE HURON.

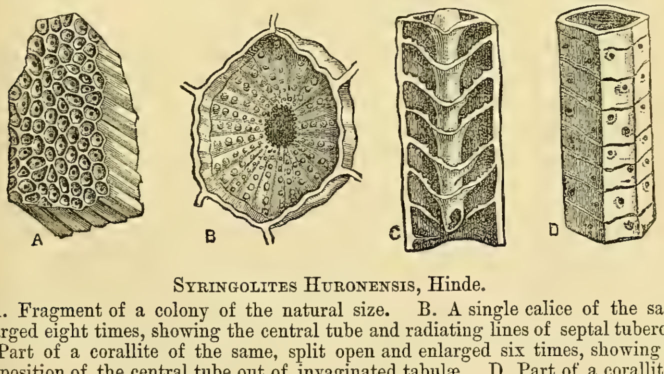
By G. JENNINGS HINDE, F.G.S.

CERTAIN zones of the massive grey dolomite belonging to the Niagara Formation in North America are so largely composed of fossil corals as to indicate similar conditions of formation to that of the coral reefs of the present age. Perhaps no better examples of these Palæozoic coral reefs could be found than those which are exposed in many tracts of the surface of the Great Manitoulin Island, which are literally covered with complete and fragmentary corals in a silicified condition, which have been weathered out of the matrix of hard dolomite in which they had been imbedded. The great majority of these corals belong to the well-known genera *Favosites*, *Halysites*, *Heliolites*, *Alveolites*, *Cœnites*, *Syringopora*, *Strombodes*, *Cyathophyllum*, *Zaphrentis* and *Omphyma*, and many of the species are also common to the Silurian rocks of Europe. A recent search in the débris of one of these ancient reefs has brought to light a coral which appears to belong to a new genus, with the following characters.

SYRINGOLITES, gen. nov.

Gen. char.—Corallum composite, growing in large flattened masses with a basal epitheca. The corallites are polygonal, comparatively thin-walled, closely in contact, vertical in their direction of growth, and with one or more rows of mural pores on each of their prismatic sides. In the centre of each corallite is a cylindrical tube, with non-perforate walls, formed apparently by the invaginated extension of a series of funnel-shaped tabulæ. This median tube appears to be continuous as a rule, though rarely a thin horizontal plate may be seen crossing it. The upper surface of the funnel-shaped tabulæ carries numerous well-marked rows of short septal spines or tubercles, which converge from the sides of the corallites to the central tube into which they also extend. In certain examples the walls of the calices are crenulated by vertical septal ridges.

Obs.—The only genus with which the above is at all closely allied is that of *Rœmeria*, Edwards & Haime (Polyp. Foss. des Terr. Pal. p. 253). This genus was formed to include the single species of *Calamopora infundibulifera*, Goldfuss (Petrefacten Germ. part i. p. 78, plate xxxii. figs. 1 *a*, *b*), and is thus described: "Polypier en masse arrondie, polypiérites unis par leurs murailles; planchers infundibuliformes." In the description of the only species of the genus the authors further add, "Nous ne savons pas, s'il existe réellement des trous aux murailles." The above generic description is of so wide and general a character that it would certainly include my new form, and at first disposed me to refer it to *Rœmeria;* but having had the opportunity (for which I am indebted to the obliging courtesy of Professor Andrea, of Bonn) of making a close examination of the original specimens, upon which Goldfuss and Edwards & Haime based their descriptions, I find that the differences are too great to allow the forms in question to be placed in the same genus. Thus in *Rœmeria* (*Calamopora*) *infundibulifera,* the corallites have unusually thick walls, and are not in contact at their summits, which are circular. There is, further, the very important fact, that no mural pores can be distinguished in the specimens, notwithstanding the statement of Goldfuss that such existed; and the character of the corallite walls, and their separation from each other at the surface of the corallum, tends to negative the probability of their presence. Again, there is no appearance in the type specimens of the open central tube as shown in Goldfuss' figure (plate xxxii. fig. 1 *b*), but there are, instead, funnel-shaped tabulæ resembling those present in the genus *Syringopora,* consisting of a series of elongated closed cones closely fitting into each other. The specimens of *R. infundibulifera* may, indeed, be compared to a *Syringopora,* in which the connecting processes are absent, and the corallites are in contact with each other. There are, besides, no indications in *Rœmeria* of septal spines. It is thus apparent that there is sufficient divergence in the characters of *Rœmeria,* as shown in the only known examples of the genus, and *Syringolites,* to justify the separation of these forms into distinct genera.



Syringolites Huronensis, Hinde.

A. Fragment of a colony of the natural size. B. A single calice of the same, enlarged eight times, showing the central tube and radiating lines of septal tubercles. C. Part of a corallite of the same, split open and enlarged six times, showing the composition of the central tube out of invaginated tabulæ. D. Part of a corallite of the same viewed from the exterior, and enlarged six times, showing the mural pores.

The only difference between *Syringolites* and *Favosites* (Lamarck) (= *Calamopora,* Goldfuss) consists in the central tube and the rows of septal spines on the tabular surfaces and in the tube of the corallites of the former genus; in all other respects, the resemblance between the two genera is very close.

The absence of connecting processes, the mural pores, and the open character of the central tube, sufficiently distinguish *Syringolites* from *Syringopora*.

SYRINGOLITES HURONENSIS, sp. nov.

Besides the above-mentioned generic characters, it may be added that the upper surface of the corallum is nearly flat; the walls of the corallites are well defined, and occasionally possess a wavy outline. The calice formed by the uppermost tabula is moderately deep, and gradually slopes from the sides to the central tube. The corallites are of generally uniform size, about one line in diameter, the central tube is about $\frac{3}{8}$ line wide, and the tabulæ are about $\frac{1}{3}$ line apart. There are on the upper surfaces of the tabulæ about twelve complete rows of septal tubercles or spines extending from the sides of the corallites to the central tube, and between these are incomplete rows, which only reach part of the distance. The central tube is of nearly uniform diameter throughout. The mural pores occur at irregular intervals, and appear to alternate with each other.

The specimens are all silicified and free from the dolomitic matrix, so that their characters are very distinctly shown. Not infrequently the central tube has been filled up with silica, and in this condition it presents the appearance of a solid columella, for which it might be mistaken.

Formation and Locality.—Not uncommon in the Niagara dolomite (Wenlock), near Manitouwaning, Great Manitoulin Island, Lake Huron.

III.—ON SOME RECENTLY DISCOVERED TEETH OF *OVIBOS MOSCHATUS*, FROM CRAYFORD, KENT.

By WILLIAM DAVIES, F.G.S.,
of the British Museum.

THE great geological interest which attaches to the fossil remains of the Musk-ox or Sheep (*Ovibos moschatus*, Blainv.), found in British Pleistocene deposits, and the few instances hitherto recorded of their occurrence (together with a recent discovery brought to my notice), have suggested to me the desirability of a brief enumeration of them.

They consist respectively of a portion of a skull, from the low-level Thames gravel, near Maidenhead, first described by Prof. Owen;[1] a fragment of a skull from the gravels of Green Street Green, near Bromley, Kent; both of which are preserved in the British Museum; "fragments of the skulls of a male and female, from the gravels of the Avon at Freshford, near Bath;" a "basal portion of a skull obtained from the gravel of Barnwood, near Gloucester;" and, "a nasal bone, a tibia, and an astragalus, from the low-level gravels of Fisherton," near Salisbury; and, lastly, "the head of a fine bull, wanting the facial bones, discovered and exhumed by Prof. Boyd Dawkins, from the lower

[1] *Bubalus moschatus*, Owen; Quart. Journ. Geol. Soc. vol. xii. (1855), p. 124.

brick-earths of the Thames Valley, at Crayford, Kent.[1] Of these nine specimens, six are fortunately characteristic portions of the skull, these being the most important factors in the verification of the species, and its authentication as a British fossil. Nevertheless, its remains are so rare, that any new discovery of characteristic fragments which add to the evidence are of sufficient scientific value to be placed upon record; and such evidence is afforded by the discovery of the molars of a mandibular ramus, which I detected amongst a series of miscellaneous mammalian remains, recently obtained from the brick-earth at Crayford, and which were submitted to me for examination by my friend, Robert Cheadle, Esq., F.G.S.

The specimens consist of the three true molars and the fourth premolar of the right side. They were found *in situ* in the jaw, but unfortunately the bone was too decomposed and friable to be preserved. The first molar is imperfect, the others are entire and in good preservation, and they belonged to a large and fully mature animal, the last lobe of the third molar having just come into wear. They greatly resemble in their general form and characters the teeth of *Ovis* and *Capra*, inasmuch as they have no supplementary lobe in the external valleys of each molar, in their simpler structure, and in being much more compressed laterally, than are the teeth of *Bos* or *Bubalus*.

That they belonged to an individual of large size is inferred from the measurements of the teeth as compared with the teeth in a lower jaw of a recent Musk-ox, of about the same age, in the British Museum (612 *f*), and with which, excepting size, they agree in all essential characters. These measurements in inches and tenths, are as follows:—Combined length of series of four last molars *in situ*—Fossil, 5·6; Recent, 4·5. Measurements of teeth, separately:

	Fossil.				Recent.			
	M. III.	M. II.	M. I.	P.M. M.	M. III.	M. II.	M. I.	P.M. IV.
Antero-posterior length	1·85	1· 4	1· 1	0·85	1· 6	1·12	0· 9	0· 8
Transverse diameter of anterior lobe	0·75	0·78	0·75	0· 5	0· 6	0· 6	0·59	0·45
Do. do. second lobe	0·64	0·73	0· 7	0·44	0· 5	0·58	0·57	0·41
Do. do. third lobe	0·35				0·32			

The recent jaw I assume to be the specimen from which Prof. Boyd Dawkins obtained the measurements given in his Monograph (*op. cit.* p. 13), as they exactly coincide with those given above, taken by myself.

With regard to the position in the brick-earth, Mr. Cheadle informs me that the teeth were found in the well-known chalk-pit

[1] See an exhaustive memoir upon the osteology, geographical range, and geological distribution of this interesting Arctic animal, by Professor Boyd Dawkins, F.R.S., "Pleistocene Mammalia," Part V. (*Ovibos moschatus*); in the Monographs of the Palæontographical Society for 1872.

through the tunnel, and in the clay near the zone of the "*Cyræna* bed." This, although in the same deposit, would be at a higher level than that of the skull already mentioned, and, therefore, cannot be supposed to have belonged to it. The deposit is rich in remains of Mammalia, both of extinct and still existing species; the teeth and bones of Elephants, Oxen, Deer, and the Horse predominating; those of the Rhinoceros (three species), although frequent, are far less common; whilst the remains of Carnivora are rare.

Whether these brick-earths are Pre-glacial, as Prof. Dawkins supposes them to be, or, as more generally considered by geologists, belong to a later period than the true Glacial epoch, they contain, curiously commingled, the *débris* of animals which were respectively inhabitants of temperate and of rigorous climes. The species, excluding the Invertebrata, whose remains are recorded as having been found at Crayford, are the following:—

Ursus ferox, Linn.	*Cervus elaphus*, Linn.
,, *arctos*, Linn.	*Elephas antiquus*, Falc.
Felis spelæa, Goldf.	,, *primigenius*, Blum.
Hyæna spelæa, Goldf.	*Equus fossilis*, Mey.
Canis lupus, Linn.	*Rhinoceros tichorhinus*, Cuv.
Bison priscus, Ow.	,, *leptorhinus*, Ow.
Bos primigenius, Boj.	,, *megarhinus*, Christ.
Ovibos moschatus, Blainv.	*Arvicola amphibia*, Desm.
Megaceros Hibernicus, Ow.	*Spermophilus erythrogenoides*, Falc.

The fossil remains of the Musk-ox are as equally rare in the Upper Tertiaries of the European continent as in England. Prof. Dawkins cites three localities in France, and four in Germany, where its remains have been discovered. They have also been found in three places in Siberia; and also in the frozen mud cliffs of Eschscholtz Bay, on the coast of Arctic America, but nowhere abundantly; and only in one instance, and that a single tooth, "in the gravel of the Oise," near Chauny, France, have the teeth, previously to those here described, been found. It is assumed, on account of the paucity of its remains in Europe, that it was only an occasional wanderer so far south of its usual habitats.

The distribution of the existing Musk-ox is at present limited to the barren lands of Polar America, between the 60th and 83rd parallels of latitude. During the late Arctic Expedition a fine bull was shot near the coast of Grinnell Land, in latitude 82′ 27″; the stuffed skin of which is exhibited in the National Collection.

IV.—The Glacial Period in Eastern America.

By Prof. C. H. Hitchcock.

Recent studies of the glacial phenomena as exhibited in the State of New Hampshire and adjoining regions enable us to maintain the following propositions.

1. The ice-sheet at the time of its maximum development passed south-easterly over all New England, New Brunswick and Nova Scotia. It came from the St. Lawrence Valley, where all the

observed striation is at right angles to this south-east course, and travelled directly over the highest ridges and summits towards the sea. I find upon the summit of Mount Washington boulders weighing 90 lbs. that have travelled certainly ten miles and ascended as much as 4000 feet above their source. I also find striæ and 'till' there. Heretofore the top of this mountain, 6291 feet above the sea, has been regarded as a glacial island.

2. In the decline of the ice period local glaciers radiated from the White and Green Mountains. Those passing southerly were the most conspicuous. Their traces consist partly of striæ, and, in their absence, of transported material. Careful preliminary studies of the position of the several formations has made such identification possible.

3. The till consists of two parts, called lower and upper, and believed to be the equivalents of the corresponding parts of the till of the British Islands. The lower consists of bluish compact earth containing small striated and far-travelled boulders, with occasional lenticular gravel sheets. Its iron oxide is mostly ferrous, the same as that of the rocks before transportation. The upper till is universal; is a reddish-brown loose material with imbedded and overlying rough blocks of large size which have usually travelled a short distance. The iron oxide is hydrous ferric. The description of the common varieties of the Scottish till, by James Geikie, in the *Great Ice Age*, second edition, p. 116, seems to agree with this. All these facts, especially the condition of the iron oxide, necessitates the belief that our lower till is the proper ground moraine, while the upper till consists of all the ice-borne materials (lateral, median and much of the terminal moraines with imbedded detritus), which fell upon the subjacent hard face when the ice melted. The upper till would therefore cover the lower deposit uniformly and universally, save where enormously accumulated in the terminal or frontal moraines; and the original anhydrous ferrous oxides would absorb water and oxygen by exposure to air and water during the melting process. Careful analyses confirm our impression of this diverse nature of the iron oxides.

4. No facts seen confirm the theory of the presence of a universal interglacial warmer period. The few marine beds lying between the two tills contain boreal fossils, or the remains of such animals as now flourish in Greenland, and they are covered only by our upper till. A true ground moraine never overlies the interglacial beds. An excellent case may be seen at Portland, Maine, where we find, first, enormous deposits of lower till; second, marine beds (called Champlain) containing 121 species of fossils, reaching to 100 feet above the present sea-level, thus indicating a submergence of that amount; third, deposits of upper till, 25 feet thick, covering uniformly both the lower till and the marine beds. Recent excavations made in grading the streets show these facts incontestably. Hence it seems plain that for a brief period the glacier retreated a short distance, allowing the marine beds to accumulate just as they do now in Greenland; then the ice re-advanced so as to cover the

fossiliferous deposit, bringing a load of coarse ferric material, but no ground moraine. The ice soon melted, and thus the upper till was precipitated upon the previously formed floor. In the Champlain and St. Lawrence valleys no occurrence of till overlying the marine beds has yet been observed; so that the recurring glacial conditions were too insignificant to cause a re-advance of the ice-sheet less than 200 miles to the north of Portland.

5. All the facts of striation and drift dispersion from the Gulf of St. Lawrence to the Rocky Mountains are best explained by the existence of a central *mer de glace* in the Labrador peninsula, or somewhat farther west. Torell and Dana have maintained that the starting-point of the glacier was in Greenland; but we find (a) the glacial movements from the Labrador peninsula have been *towards* Greenland instead of away from it; (b) the Greenland ice must have been twenty-two miles high to flow to the Saskatchewan region; (c) the bridging of Davis Straits could be hardly possible.

6. The Labrador plateau is lower than the New England hills. To overcome this difficulty Professor Dana supposed there had been an elevation of the northern Laurentian watershed, sufficiently gigantic to allow of a south-east sliding of the ice. There is no evidence of such elevation of the land beyond the requirements of the theory. It will be easier to accept Dr. Croll's view that the ice-sheet itself became miles in thickness, by the gradual retention of frozen moisture, and moved then as readily as if a less amount capped high mountains. It first moved south-westerly as far as Manitoba, Dakota, and Missouri; then when the St. Lawrence Valley became filled to the brim, the surplusage moved towards the Atlantic in a south-east direction. Either of these theories is extreme; but there seems to be no escape from accepting one of the two horns of the dilemma.

7. The south edge of the American ice-sheet is well marked by the presence of enormous terminal moraines, coupled with extensive sand and gravel plains washed from the glacial debris by the waters derived from the melting ice. The eastern extremity is at Cape Cod, Massachusetts, and Long Island, New York. These long drift hills, consisting largely of gravel and sand, are isolated from all present appearance of connexion with any possible higher land from whence the depositing waters could have flowed. By supposing that they formed the front of the glacier just before its decadence, it is easy to understand both how an immense supply of drift material was furnished, and the origin of the freshwater streams which formed plains and hummocks of stratified sand far above the present water-level. A study of the writings of all the State geological reports enables us to discover more than one continuous moraine line, from Massachusetts to the Red River country west of Manitoba, save in a portion of Pennsylvania, which needs further study.

V.—Pleistocence Geology of Cornwall.[1]

By W. A. E. Ussher, F.G.S.

Part IV.—Submerged Forests and Stream Tin Gravels.

THE evidence under this head is necessarily a compilation; the very exceptional exposure of the old forest ground, and the nature of stream tin sections, leaving no room for personal investigation. The names of the observers are in most cases sufficient vouchers for the accuracy of their statements. The submerged forests are given first, as there is no evidence forthcoming to show the priority of the stream tin gravels to the general growth of the forests. The forest bed overlying the stream tin which Mr. Carne rightly synchronizes with the forest beds on the coast may represent a very brief portion of a long period of forestial growth.

Submerged Forests.—Proceeding round the coasts from Plymouth.

1. Looe. Mr. Box (26th Ann. Rep. Royal Inst. Corn. for 1844) noticed trunks of oak, alder, ash, and elm, on Millendreath Beach, in vegetable mould extending for 250 yards from east to west, and sloping from below high-water mark to the southward for 150 feet, where it was lost sight of under fine sand, which, though explored for 30 feet farther out, yielded no further traces. The plants in the mould resembled those found in a neighbouring marsh, 130 feet above high water, of which the following section is given:—

Peat of flags and arundaceous plants.
Dark brown vegetable matter with holly and alder.
Layer of sand with vegetable matter, numerous hazel nuts, and the elytra of Coleopterous insects, also black oak and ? holly, resting on firm light-coloured clay.

Numerous angular slate fragments were met with, but no shells.

2. Near Mevagissey. Sir C. Lemon (T. R. G. S. Corn. vol. vii. p. 29) gives the following section disclosed in cutting a drain at Heligan (about a mile inland from Mevagissey Bay) near the foot of a hill 20 feet above the stream in the valley bottom, and in another place, higher up, at 40 feet above the stream:—Loam 1 foot 8 inches from the surface, upon a mass of whitish, bluish, and yellowish clay with broken slate, with the stump of an oak 4 feet long and nearly a foot in diameter, 7 feet 4 inches from the surface at its lower extremity.

Submerged forests have been observed after severe gales—

3. At Fowey by Mr. Peach (T. R. G. S. Corn. vol. vii. p. 62), the trees being rooted in stiff clay.

4. At Porthmellin, near Mevagissey (*Ibid*, vol. vi. pp. 23 and 51), the roots resting on clay apparently *in situ.*

5. At Maen Porth, near Falmouth, by the Rev. J. Rogers (*Ibid*, vol. iv. p. 481), the roots being in clay.

6. At Porthleven near the Loo Pool, by the Rev. J. Rogers (*Ibid*, vol. i. p. 236), oak and willow roots apparently *in situ.* At Fowey and Porthmellin, elytra of beetles were found.

7. Mr. H. M. Whitley (Journn. R. Inst. Corn. No. 13, p. 77) gives

[1] Continued from the May Number, p. 211.

the following section at Market Strand, Falmouth, exposed during excavations at the Landing Pier:—

Layer of sand on a thin bed of shale, thinning out seaward ...	2ft.	0in.
on—Forest Bed, compact peat, flags, ferns, trees of oak, hazel, fir, beech; fir and beech most abundant; no hazel nuts obtained	7ft.	0in.
The top of this bed occurred at about the level of ordinary spring-tide low-water mark. Its base rested on a layer of gravel	4ft.	0in.

Mr. Whitley was informed that the forest bed extended for a short distance up the valley, and that another part of it had been met with in an excavation at Bar Pools. The open space before the market is called "the Moor."

8 *a*. Mounts Bay. Leland thus alludes to the submerged forest in Mounts Bay—"In the Bay betwyxt the Mont and Pensants be found near the lowe water marke Roots of Trees yn dyvers places as a token of the ground wasted."

b. Dr. Borlase (Trans. Roy. Soc. for 1757, p. 80) noted the discovery of roots, trunks, and branches of oak, hazel, and willow, on the shores of Mounts Bay, in black marsh earth with leaves of *Juncus*, under 10 feet of sand.

c. Dr. Boase (T. R. G. S. Corn. vol. iii. p. 131) mentioned the occurrence of vegetable mould with roots and trunks of indigenous trees, under 2 to 3 feet of sand on the west of St. Michael's Mount.

d. Mr. Carne (T. R. G. S. Corn. vol. vi. p. 230) noticed the occurrence of trees on peat, east of Penzance, the largest being an oak trunk with bark on, 6 feet long and $1\frac{1}{2}$ feet in diameter.

e. He also mentioned the occurrence of a peat bed 3 to 8 feet thick in the low tract between Marazion and Ludgvan (a reclaimed marsh); it extends for 2 miles, from a little eastward of Chyandour to the Marazion River. Near Longbridge, where it approaches the surface, it is from 4 to 7 feet thick, and used for fuel; it rests on a thick bed containing *Cardium edule*, and is generally concealed by alluvium.

9. Mr. Henwood (40th Annual Rep. R. Inst. Corn. for 1858) describes a submarine forest on Dunbar Sands in the Camel Estuary. Nothing save spongy masses of peaty sand were visible in 1875, when I visited the spot, the roots, etc., having been probably washed away in the interim.

10. De la Beche says that traces of submarine forests were noticed at Perran Porth, Lower St. Columb Porth, and Mawgan Porth. (Report, p. 419). No signs of them were visible on the occasion of my visit. St. Columb Porth is a sand flat, at low water, between cliffs not 10 feet in height, exhibiting no traces of old marine action. Mawgan Porth is a similar sand flat, but broader, and terminating in low sand dunes, to the south of which narrow strips of alluvium border the streams.

11. Bude. Mr. S. R. Pattison (T. R. G. S. Corn. vol. vii. p. 35) noticed roots of trees of large size, apparently *in situ*, in dark clay, at Maer Lake, near Bude Haven.

12. Mr. Pattison also noticed large accumulations of bog timber in the Fowey Valley on Bodmin Moor. At Bolventor the heads of the trees pointed down the valley.

Stream Tin Sections.

1. De la Beche (Report, p. 405) says that in the interior the tin ground is usually covered by river detritus, more open spaces frequently having a bed of peat (in which oaks are common) interposed between the tin ground and other detrital accumulations, as in Tregoss Moor and the moors adjacent to Hensborough. "In some whole ground (stream tinners' term for stanniferous gravel) and superincumbent beds not previously disturbed by the old men, upon Bodmin Coast Moor, the peat beds with oak, alder, etc., covering the tin ground very irregularly, were in some places several feet thick, in others absent, though on the whole they seemed to keep a somewhat common level above the tin ground. In some places thin peat beds had been accumulated at still higher levels among the gravels, sands, and clays. The shelf composed of semi-decomposed granite was very irregular, holes 30 or 40 feet deep presenting themselves, in the bottoms of which there was usually good stanniferous gravel."

2. Mr. Pattison (*op. cit.*) gives a section of the Fowey Valley Works, in which the (hard and black) forest bed was met with at from 23 to 27 feet below the surface, resting on stream tin gravel, and overlain by sand with a peat bed containing ferns and hazel. The granite shelf, tin gravel, and forest bed presented a faulted appearance.

3. Par. De la Beche (Report, p. 403). In cutting the Par Canal at Pons Mill, near St. Blazey, granite blocks, as if arranged for a bridge, were found beneath 20 feet of gravel, probably in part resulting from stream tin washing. Section in low ground near the Par Estuary—

1. River deposits	1ft. 6in.
2 and 3. Mud, sand, clay, stones, much disturbed by the stream tinners in the upper part; with vegetable matter in the lower part	15ft. 0in.
4. Fine sand with sea shells like cockles, and rolled pebbles in the upper part	4ft. 0in.
5. Mud, clay, sand, wood, nuts, etc., mixed	3ft. 0in.
6. Tin ground resting upon an uneven surface of slate ...	6in. to 6ft. 0in.

4. North of St. Austell. Mr. Henwood gives the following sections. The letters prefixed denoting beds probably contemporaneous. (T.R.G.S. Corn. vol. iv. pp. 60 to 64.)

A. Merry Meeting, in parish of St. Roche.

a. Mud, with decayed vegetable matter	2ft. to 3ft.
1. Granitic gravel	2ft.
2. Silt, with decayed vegetable matter and plates of mica ...	4ft. to 5ft.
b. Granitic stones, gravel and sand mixed with silt and nuts ...	4ft.
3. Vegetable matter (locally called Fen), moss, grass, wood (? charred)	1ft.
4. Silt (vegetable remains ?)	1ft.
5. Vegetable remains (charred like No. 3)	1ft. to 3ft.
6. Vegetable matter passing into silt	8in. to 10in.
c. Tin ground, with enormous quartz blocks, some 15 ft. square; tin ore as sand, stones, and pebbles mixed with quartz, granite, and schorl rock; little rounded, and of the best quality where the decomposed granite shelf is softest... ...	4ft. to 30ft.

B. In the centre of Pendelow Vale.

a. Granitic sand and gravel	12ft.	0in.
1. Silt (vegetable matter ?)	1ft.	0in.
2. Granitic sand	4ft.	0in.
3. Vegetable matter (like No. 5 in other sections, but with sand)	2ft.	0in.
b. Silt, sand and gravel mixed	2ft.	0in.
4. Vegetable matter (like No. 5 in other sections) (Fen) ...	4ft.	0in.
5. Tin ground, ore not abundant, most plentiful near the base	5ft.	0in.

C. Watergate.

a. Mud with granitic sand and gravel	5ft.	0in.
1. Fine granitic sand	2ft. to 3ft.	0in.
2. Silt (with decayed vegetable matter ?)	2ft.	6in.
3. Fine granitic sand	2in. to 3in.	
4. Silt (resembling No. 2)	3ft.	0in.
b. Silt, sand, gravel, and large stones, indiscriminately mixed	3ft.	0in.
5. Vegetable matter passing into silt in the lower part (like Nos. 5 and 6 in the Merry Meeting section)	5ft. to 6ft.	
c. Tin ground; the ore occurs as sand and pebbles	2ft. to 20ft.	

D. Broadwater, Luxillion. Tin ore much larger towards the sea than up the vale. A patch of slate some hundreds of feet in area was found resting on tin ground, and apparently unconnected with the shelf.

a. Granitic sand	6ft. to 7ft.	0in.
b. Mud, apparently of vegetable origin, mixed with granitic sand and gravel	4ft. to 5ft.	0in.
c. Tin ground; ore, small pebbles not much rounded ...	7ft.	0in.

The tin bed is sometimes divided by a bed of granite (cap shelf) as at Grove and Merry Meeting. Numerous blocks of quartz lie on the shelf. Below the shelf (soft granite) tin ore is not abundant.

The following are from Journ. R. Inst. Corn. vol. iv. p. 214 :—

E. Levrean in St. Austell's parish.

1. Granitic sand and gravel	1ft.	0in.
2. Peat (Fen), often mixed with, and sometimes divided by, very thin layers of granitic sand	1ft.	0in.
3. Granitic matter, particles and granules of tin, rarely minute specks of gold (Upper Tin Ground)	3ft. to 6ft.	0in.
4. Angular and subangular masses of granite in granitic sand without any tin ore (False Shelf)	1ft. to $1\frac{3}{10}$ft.	0in.
5. Tin ground; angular and subangular granite, felspar, quartz, schorl, veinstone materials mixed with granitic gravel and sand, grains and particles of tin oxide, and less frequently flakes of schistose matter with specks of gold. A few ancient shovels of wood, bound on the edges with iron, have been found in this bed. The shelf is of granite of unequal hardness	10ft. to 15ft.	0in.

F. Pit Moor in St. Austell's Parish.

1. Vegetable mould	1ft.	0in.
2 and 3. Granitic detritus in many layers	5ft. to 6ft.	0in.
4. Tin ground; angular, subangular, and rounded masses of granite, quartz, schorl, veinstones, small quantities of tin ore; clay-slate laminæ, occasional; on soft granite shelf	3ft. to 10ft.	0in.

G. Upper Creamy (Wheal Prosper).

1. Peat	0ft.	6in.
2. Granitic clay, often mixed with laminæ of yellowish slate	1ft. to 3ft.	0in.
3. Tin ground; small angular and rounded granitic and		

veinstone material; tin stone as sand and gravel; microscopic particles of gold. On shelf of bluish and brownish clay. The roots of marsh plants penetrate the tin ground	4ft. to 5ft. 0in.

H. N.W. of the Railway Bridge over the high road between Lanivet and the Indian Queens.

1. Vegetable mould	6in. to 1ft.
2. Angular and subangular stones of quartz, slate, elvan, schorl rock, slate veinstones, and occasionally granite	3in. to 4ft.
3. Tin ground like the overburden, but with rounded masses of tin ore, often very small; on shelf of clay slate	1ft. to 2ft.

I. Gun-deep in St. Denis.

1. Vegetable mould	6in. to 1ft.
2. Gravel, stones of slate, quartz, elvan, schorl rock, and occasionally granite	4ft.
3. Peat	1ft.
On 4. Tin ground; poor.	

J. On N. side of Tregoss Moor. Ancient works resumed at Golden Stream about half a mile S.E. of Castle-an-dinas in St. Columb Major.

1. Vegetable mould	0ft. 6in.
2. Angular and subangular masses of slate, quartz, elvan, schorl rock, veinstones, and occasionally granite; lumps of peat had been previously removed from this bed	5ft. to 6ft. 0in.
3. Tin ground resembling the overburden, but with more numerous fragments of elvan; the tin ore as gravel or sand	2ft. to 3ft. 0in.

K. Dr. Boase (T.R.G.S. Corn. vol. iv. p. 248) mentioned the occurrence of siliceous sand under diluvial debris in the Stream Works near Hensborough, on the road to Roche. At Tregoss and Roche the tin ground contained quartz and schorl pebbles, and the shelf consists of decomposed slaty felspathic rock.

L. Henwood (J.R. Inst. Corn. vol. iv. p. 230). Section at Penny Snap (Wheal Prosper, in Alternun) E. of the Drains River—

1. Peat	7ft. 0in.
2. Angular and worn granite, elvan, schorl, and quartz stones in pale blue felspathic clay, averaging	5ft. 0in.
3. Tin ground as above, with tin ore as waterworn sand or gravel; on granite shelf	3ft. 0in.

5 *A.* The section of the Happy Union Works by Mr. Colenso (1829) has been quoted by several writers, but by none more fully than De la Beche, from whom I extract (Report, pp. 401, 402, 403), giving the deposits in reverse order.

1. Rough river sand and gravel, here and there mixed with sea sand and silt. A row of wooden piles with their tops 24 feet from the surface, apparently intended for a bridge, were found on a level with spring-tide low-water	20ft. 0in.
2. Sand; trees all through it, chiefly oaks, lying in all directions; animal remains, bones of red deer, hog, human skulls (?), bones of whales.	20ft. 0in.
3. Silt or clay and layers of stones, a conglomerate of sand, silt, bones and wood	2ft. 0in.
4. Sand with marine shells; water draining through this bed is salt above, fresh below	0ft. 4in.
5. Sludge, or silt, brownish to a lead colour in places, with	

recent shells which, particularly the bivalves, are often in layers, double and closed, with the siphonal end upward, rendering it likely that they lived and died there; they are of the same species as those existing in the neighbouring sea; wood, hazel nuts, and occasionally bones and horns of deer and oxen are found in this bed: a piece of oak, shaped as if by man, with a barnacle attached, was found at 2 feet from the top	10ft. 0in.
6. A layer of leaves, hazel nuts, sticks, and moss (in a perfect state, almost retaining its natural colour apparently where it grew). It extends, with some interruptions, across the valley, occurs at 30 feet below low-water mark, and about 48 feet below spring-tide high-water...	6in. to 12in.
7. Dark silt, apparently mixed with decomposed vegetable matter	1ft. 0in.
8. Roots of trees in their natural position; oaks with fibres traceable for 2 feet deep. "From the manner in which they spread there can be no doubt but that the trees have grown and fallen on the spot where their roots are found." Oyster-shells still remain fastened to some of the larger stones and to the stumps of trees...	
9. Tin ground, with rounded pieces of granite, and subangular pieces of slate and greenstone. Most of the tin occurs in the lower part, from the size of the finest sand to pebbles 10lbs. in weight; some rocks richly impregnated with tin weigh 200lbs. and upwards. Thickness (including No. 8) from	3ft. to 10ft.

B. De la Beche (Report, p. 403) says, "These works are now abandoned," others on S. of London Apprentice Inn were carried on in 1837: "from which it would appear that from the general rise of its bottom, the sea had not entered this valley sufficiently high to permit marine deposits to be there accumulated." This probably refers to Mr. Colenso's section of Wheal Virgin Works (T.R.G.S. Corn. vol. iv. p. 38), a mile from Happy Union, in which no sea sand was found. The tin ground betraying signs of old men's workings lay beneath 32 feet of silt and river gravel, with oak, willow, etc., in considerable quantity, with their roots in situ where soil exists. "How far," says Mr. Colenso, "Pentuan Valley extended seawards is conjectural, but at its present declivity of 45 feet to a mile between St. Austell and Pentuan, it must have continued a mile further than it does now." Mr. Smith (*Ibid*, p. 400) mentions the rapid descent of the valley from Hensborough (900 to 1000 feet in height), and the continuance of a bed of pebbles all the way.

C. Section of Lower Pentewan work, quarter of a mile from the beach given by Mr. Smith (*op. cit.*)—

1. Soil with growing trees, some very old; gravelly towards the bottom	3·3
2. Fine peat, roots of trees, fallen trunks, sticks, ivy, sea laver, rushes, impregnated with salt	12·152
3. Sea mud, with compressed leaves at the top, cockles at 31 feet from the surface, bones, human skulls (one of a child) deer horns. At the bottom, a bed of very small shells a foot in thickness	20·35
4. Sea mud, oysters, and cockles	4·39
5. Compressed leaves, vegetable matter, a few rotten shells	6½·45½
6. Vegetable matter, rushes, fallen trees, leaves, roots, moss, the wings of Coleopterous insects	1·46½

7. Moss, hazel nuts, sticks, on pebbles of killas, growan, etc.	3·49½
8. Rough tin ground, stones light and poor	2·51½
9. Rough tin ground, rich stones with quartz pebbles and yellow ferruginous clay. Killas at about low-water mark	3·54½

D. (*op. cit.*) Section of Upper Pentuan works, 1 mile N. from the beach, where the valley is half a mile wide.

1. Soil with trees growing on it	3ft.	3in.
2. Mud with gravel seams resembling false bedding	21ft.	11in.
3 and 4. Spar and killas upon growan, spar, and killas ...	12ft.	9in.
5. Gravel, with trees and branches of oak of great size at the bottom	8ft.	0in.
6. Tin ground	8ft.	5in.
7. Clay, in which were found the roots of a vast oak, and a branch 4 feet long and 3 inches in diameter, projecting from the wall of the work. A second mineral deposit may occur below this.		

E. Mr. Smith also gives a section of Pentowan work (either a place near Pentuan, or a misprint) in 1807.

Sandy clay, stones, gravel	9ft.	0in.
Peat with roots and leaves	7ft.	0in.
Sand with branches and trunks of trees	8ft.	0in.
Finer sand, with shells, bones, horns, vertebra of a whale, human skulls	12ft.	0in.
Coarse gravel	2ft.	0in.
Close sand with clay, becoming peaty near the base	12ft.	0in.
Loose stones and gravel, 1 foot thick, resting on tin ground.		

Falmouth district.

F. Tregoney Stream Work in 1807, given by Mr. Smith (*op. cit.*).

1. Granitic gravel with layers of sand	11ft.	6in.
2. Black mud with shells (a cow's horn and horns of stags)	15ft.	0in.
3. Tin ground ... ... averaging	2ft.	0in.

6. In Journ. Roy. Inst. Corn. vol. iv. p. 204, etc., Mr. Henwood gives the following sections in two places, where the bed of Restronguet Creek is some 12 feet below spring-tide high-water.

A. Section 1.—

1. Mud of the river, very soft...	6ft.	0in.
2. Mud and coarse sand	8ft.	0in.
3. Mud (hardened)	6ft.	0in.
4. Mud (with numerous oyster shells)	12ft.	0in.
5. Mud (hardened)	31ft.	0in.
6. Tin ground, 6 inches to 6 feet thick ... ...averaging	4ft.	0in.
Shelf of buff or blue clay slate.		

B. Section 2.—

1. Soft river mud	7ft. to 9ft.	0in.
2. River sand and mud	9ft.	0in.
3. Blue mud (shells of oyster, cockle, etc.)	9ft.	0in.
4. Stiff blue mud without shells	36ft.	0in.
5. Tin ground; subangular masses of granite, slate, elvan, quartz, etc., and tin ore in large masses interspersed with smaller grains, 6 inches to 6 feet thick; ... averaging	4ft.	0in.
Shelf of clay-slate.		

De la Beche (Report, p. 403). Up the Carnon Valley in the direction of St. Day, the tin ground is partly covered by marine sediments, partly by common river detritus.

Carnon. Mr. Carne mentioned (T.R.G.S. Corn. vol. iv. p. 105) some beds of slate found reposing on the tin ground in the Carnon Valley, unconnected with the sides and bottom.

C. Mr. Henwood (T.R.G.S. Corn. vol. iv.) gives the following section of Carnon Stream Works, the letters denote beds probably contemporaneous with those in the Watergate, Merry Meeting, and Broadwater sections.

a. Sand and mud; 2 beds; river wash	3ft.	0in.
2. Silt and shells; 3 successive beds	0ft.	10in.
3. Sand and shells (a stream of fresh water percolates through this bed)	2ft.	0in.
4. Silt; 3 beds	12ft.	0in.
5. Sand and shells	3ft. to 4ft.	0in.
6. Silt with numerous shells	12ft.	0in.
7. Silt with stones in places	18ft. to 22ft.	0in.
b. Wood, moss, leaves, nuts; dark coloured as if charred; a few oyster shells; animal remains, chiefly cervine; human skulls. Towards the sea this bed gives place to silt (No. 7)	1ft.	6in.
c. Tin ground, rounded tin ore, unmixed, and in a quartz matrix and capel (quartz and schorl); from a few inches to 12 feet in thickness; ... averaging	4ft.	0in.
Rounded pieces of slate, granite, and quartz, mixed with the tin stones.		

Mr. Henwood observes that above Carnon Section, either the old forest never flourished, or it has been destroyed in the accumulation of alluvia, in which periods of peat growth and transport of vegetable matter are indicated.

Mr. E. Smith gives a section of Carnon Works in 1807 (Geol. Trans. vol. iv. p. 404).

7. Sections given by Mr. Henwood (J. R. Inst. Corn. vol. iv. pp. 200, 201) which from similarity of names seem to refer to localities lying between Falmouth and Helston.

A. 1. The Upper part of Carn Wartha.

1. Worn and unworn granitic detritus, mixed with lumps of peat, and refuse of previous operations	12ft.	0in.
2. Tin ground—granitic sand and gravel, sprinkled here and there with waterworn granules of tin ore; interspersed at intervals with blocks of granite and schorl rock ...	12ft.	0in.
Shelf of disintegrated granite.		

B. At Lezerea in Mean Vroaz.

1. Peat; with nuts and branches of hazel in deeper parts, in places...	4ft.	0in.
2. Coarse granitic gravel with occasional subangular stones of tin ore	2ft. to 3ft.	0in.
3. Granitic sand, slightly mixed at intervals with felspathic clay	2ft.	0in.
4. Tin ground, angular and subangular masses of granite and schorl rock, largely mixed with tin ore of different character from that at Carn Wartha	3ft.	0in.

"In other parts of the Moor sections of ancient works show beds of detrital matter resting immediately on the outcrop of tin-bearing veins in the granite."

C. Near Tregedna in Mawnan (? at mouth of R. Helford) vegetable mould and hardened silt, 20 or 30 feet thick, overlie a poor deposit of tin ore resting on slate shelf.

(*Ibid.*) Waterworn granules of pure gold have been found in detrital tin ore (which is less rounded than in other parts of Cornwall) near Helston.

Mr. Henwood (T. R. G. S. Corn. vol. v. p. 129) said that the valleys between Breague Church and Porthleven, and from Helston to the Loo Pool, have been streamed for tin.

Penzance District.

8. *A.* Mr. Henwood (*op. cit.* p. 34) gives a section in the valley between Huel Darlington and Marazion Mine near Newtown, at 20 to 30 feet above the sea. Sea sand with shells was found on vegetable matter, with trunks and branches of oak, willow, hazel in abundance, resting on poor tin ground on shelf at about the level of the sea.

B. At Tregilsoe (Tregilliow), on the confines of Ludgvan and St. Hilary, a section of the short shallow vale terminating in Marazion Marsh is given by Mr. Henwood (Journ. R. Inst. Corn. vol. iv. p. 197). Peat about 6 feet in thickness rests on the tin ground, divided through its entire width by a thin seam of clay, impervious to water, and running obliquely both to the shelf and to the surface. Above the clay seam, the gravel consists of angular and subangular masses of slate, quartz, veinstones, granules of crystalline tin ore, all imbedded in bluish clay. Below the clay seam, slate pebbles still prevail; elvan nodules are not uncommon, but the quartz is smaller and less frequent. Tin ore is diffused through the tough reddish-brown clay matrix. Although within a mile of granite no trace of granitic matter was found in these works.

Land's End District.

9 *A.* (Henwood, *op. cit.* p. 195). Near Bejowans, in Sancreed, section of a confluent with the little vale from Tregonebris to the coast at Lamorna.

1. Granitic sand and gravel with small angular and sub-angular stones	6ft. to 12ft. 0in.
2. Peat with nuts, branches, and roots of hazel	2ft. to 8ft. 0in.
3. A few inches of granitic sand, gravel, and pebbles, with occasional large granite boulders like the tin ground.	
4. Tin ground, rounded masses of felspathic granite and tin ore, fragments of veinstones and quartz crystals	2ft. to 9ft. 0in.

B. Mr. Henwood (*op. cit.* p. 193) mentions the sprinkling of tin ore on S.E. of St. Just, in the southern and central parts of a ravine trending from Kelynack north-westward to Pornanvon. He gives a section at Bosworlas, in a narrow strip of virgin tin ground.

1. Vegetable mould, in some parts of the glen succeeded by	2ft. or 3ft.
2. Granitic gravel, sprinkled sometimes with tin ore ...	a few inches.
3. Tin ground of granitic matter, subangular and rounded tin-bearing veinstones, pure tin stone, subangular or angular	3in. to 2ft. 6in.

The surface of the tin ground maintains a tolerably uniform seaward slope throughout the ravine.

C. (*op. cit.* p. 196). Between Towednack Church and Amellibrea, in the lower part of Cold Harbour Moor.

1. Peat	2ft. 6in.
2. Granite detritus; mixed with blue clay, and unproductive in the upper part; buff and reddish brown, with a little tin ore and tin-bearing veinstones in the lower part	3ft. 0ft.

D. On Leswhidden and Bostrase Moors, Mr. Carne (T.R.G.S.

Corn. vol. iii. p. 332) mentioned the occurrence of alluvial soil 6 to 9 feet in thickness on the shelf, and at Numphra Moor not exceeding 5 feet.

10. Mr. Henwood (J. R. Inst. Corn. vol. iv. p. 199) gives a section of the bed of a rivulet at St. Erth, near Hayle, as follows, the thickness of the deposits not being given: Gravel, sand, and mud, on peat, under which roots, trunks, and branches of trees, with quantities of mud, were found resting on tin ground, poor and not extensive.

Mr. Carne (T. R. G. S. Corn. vol. iv. pp. 105–111) gives the following general notes on Diluvial tin. Cap shelves are tabular masses of rock projecting from sides or bottom of the tin ground, so as to allow of the occurrence of tin ore under them. Copper, not found in tin gravels, probably because rarely so near the surface as tin, and in the form of sulphuret so liable to decomposition. The traces of gold met with were probably derived from undiscovered veins on the east. All the productive streams occupy valleys opening on the S. coast, whilst most of the richest tin veins are near the N. coast. The direction of the tin streams seems to have been from N.N.W. to S.S.E. In narrow valleys little tin ore is obtainable. In steep valleys all the ore is upon the shelf. In very gently sloping valleys tin ore is met with to within two or three feet of the surface, as at Chyanhall. In gently sloping valleys the tin ground is thick but poor, owing to admixture with alluvial sediments.

General Notes.

As the stream tin gravels were deposited during the last stages in the elaboration of the present drainage system, their watershed boundary can scarcely have differed much from the present; it is, therefore, only natural that, whilst the richest tin veins are near the north coast, the most productive streams occupy valleys opening on the south coast.

The position of the tin ground with reference to the sea-level in the estuarine sections is, unfortunately, seldom given. In Mr. Henwood's section on Marazion Green (8 *A*), mention of overlying alluvia seems to have been omitted; as Mr. Carne, in a section at Huel Darlington, near Marazion River, gives twelve feet of peat and gravel above the sea sand, and the surface is given in Mr. Henwood's section at twenty to thirty feet above the sea-level, the top of the marine bed would appear to be a few feet above high water (Carne, T. R. G. S. Corn. vol. vi. p. 230).

Again, in Mr. Smith's section (5 *C*) of Lower Pentuan, the shelf is said to be at low-water level, which would place the top of the upper marine bed at about forty feet above low water, which, considering the absence of marine deposits at Wheal Virgin Works (5 *B*) and Upper Pentuan (5 *D*), is out of the question; so that either the thicknesses are not given in feet and inches, or the level of the shelf is erroneous.

Mr. Carne (T. R. G. S. Corn. vol. iv. p. 47) describes the tin ground of Drift Moor Works, near Newlyn, as resting on the sides (which come to within a few feet of the surface) and bottom (forty feet from the surface) of a clay-lined basin. This is a most exceptional phenomenon, and seems to show the great erosive power of the stream tin floods rushing into and deepening a depression, very much in the manner in which giants' kettles are produced by the pestle-like friction of fragments swirled round hollows by subglacial streams. A somewhat analogous phenomenon is mentioned by Dr. Boase, which, although not relating to stream tin, I give here (T. R. G. S. Corn. vol. iii. p. 131): "A person surveying the Channel took his station on Wolf Rock, where he observed a cavity resembling a brewer's copper, and containing rubbish at the bottom; it was covered by the sea nine hours out of twelve."

The occurrence of an oblique clay seam in the tin ground at Tregilsoe (8 *B*), separating accumulations of slightly different characters, suggests the existence of bedding, true or false. The exceptional occurrence of clay shelf (4 *G* and perhaps 5 *D*) is worthy of note.

The changeable character of the deposits in stream tin sections precludes the absolute correlation of individual beds. Inland streams cannot be expected to furnish such sections as their estuaries, yet it is scarcely safe to identify tin ground, when not overlain by sediments (as 9 *C*); when composed of fine material under a thin covering of sediment with no indication of a land surface (as in 4 *G, H, I, J,* and 9*B*); or where it rests on outcropping tin veins (as 7 *B*), with the stanniferous gravels of Par (3), Pentuan (5 *A, B, C, D*), Carnon, etc. (6 *A, B, C*); whilst in some sections stanniferous deposits occur at different horizons, as 4 *E* (probably 5 *D*), 7 *B*.

To synchronize the forest remains in the various sections is unsafe, because in many valleys deposition seems to have gone on continuously, or to have been interrupted by such very brief periods of peat accumulation or undergrowth, that their relics became entirely mixed up and incorporated with the succeeding deposits, as in 4 *B, C, D, E,* and 5 *F*; also 4 *J* and 7 *A*.

The deposition of stream tin gravels evidently extended over a much longer period than is represented by the tin ground; for the very irregular wear of the sides and bottoms of their channels, and the existence of false shelf (4 *D, E*) here and there, and of masses of the surrounding rock, the apparent debris of fallen cap or false shelves (4 *A*, 5 *A*, 6 *C*), can only be accounted for by powerful streams carrying their detritus to lower levels, and occupying the energies of their upper and more torrential reaches in eroding their banks and beds into such irregular shapes as the unequal durability of the rocks permitted.

In like manner, the duration of the forest growth is not to be measured by the forest beds overlying stream tin in Marazion Marsh, Pentuan (5 *A, C*), etc., which can only be regarded as synchronous with a comparatively short part of the period; whilst the recurrence of peat beds with arboreal remains at different horizons in the stream tin sections (4 *A, B,* 5 *E,* 7 *B,* 9 *A,* 10) shows that even after the forests fringing the coasts were submerged and buried with the peat, which had accumulated around them during the last stages of their existence, it was some time before forestial growth in inland districts succumbed to unfavourable climatal conditions, and still longer before the succeeding undergrowth gave place to the bare and shrubless character presented by so large a part of western and central Cornwall now.

Although it seems only reasonable to regard the deposition of metallic detritus, as now going on, wherever the stream channels are traversed by tin veins, this process is so insignificant that as a whole the stanniferous gravels must be referred to a period considerably posterior to the raised beach formation, and, either long after the culmination of the elevation during which Head was accumulated, or in part synchronous with its accumulation, when, through greater elevation and increased rainfall, the force and volume of the streams was greater. The commencement of the forest growth is also indefinite, but subsequent to the accumulation of the Head, during the prevalence of a subsidence which produced conditions unfavourable to the existence of the tin floods as they became more suitable for its extension. So that the forest growth may have begun before the stream tin floods dwindled away, and the latter may have been partly contemporaneous with the Head. Whilst marine sediments on the forest bed or tin ground in estuarine sections (3, 5 *A*, *C*, *E*, 6 *A*, *B*, *C*, 8 *A*) prove the last great movement to have been one of subsidence, the more orderly arrangement of the deposits; the general absence of heavier far-borne detritus; the entire desertion of parts of their old channels by some of the present streams, indicate the gradual prevalence of conditions more akin to those now prevailing than to those in operation during the deposition of the stanniferous gravels.

The growth of trees, some very old, on the surface (5 *C*, *D*), shows that the latest of these changes must have been some time in operation, whilst the presence of human remains at great depths beneath the surface, at Carnon and Pentuan, and the tradition respecting St. Michael's Mount, would seem to justify the belief that the period in which the forests were finally submerged, although geologically very recent, is yet prehistoric.

As the subsiding movement gradually enabled the sea to circumscribe the forest tracts on its old fore-shore, the beach materials pushed forward would finally tend to bar the drainage of the valleys opening on the coast, and to convert the low lands into peat mosses, forming round the surviving trees till the further advance or dispersion of the beach dams permitted the sea to regain its old coast-line, entombing the forest fringes and their peaty surroundings beneath its sands. Eliminate from this all changes of level by internal movements, and explain the entombment of the forests by the lowering of level consequent on removal of gravel bars releasing the pent-up drainage, and the low district theory is presented. Without changes of level, however, it is perfectly untenable as applied to Cornwall, where the stream tin gravels indicate a greater elevation of the land (5 *B*), as at Carnon and Restronguet Creek (6 *A*, *B, C*), for instance, where the tin ground is more than sixty feet below the sea-level, whilst the estuarine deposits overlying the forest bed prove that the subsidence was progressive. Also, if the forests were submerged according to the low district hypothesis, they must have flourished under geographical conditions identical with the present, and yet these conditions have proved unfavourable to their growth on the present low lands. On the other hand, it cannot be argued that the submerged forests are mere rafts of drift wood, stranded with vegetable matter borne down by rivers, and finally buried beneath the sea sands. The traces of submerged forests are too numerous and too extensive (1, 7, 8) to be thus accounted for; in several cases, moreover, the roots are said to occur *in sitû* (3, 5, 11, ?6), and the elytra of beetles have been found (1, 6). Mr. Godwin-Austen (Q.J.G.S. vol. vi. p. 93, etc.) says: "It is diminished area and elevation which at present unfit the West of England to produce that growth of oak and gigantic fir which . . . . . seems to have clothed every portion of the region of Dartmoor, and which would still more be unfitted for it when at its lower Pleistocene level. On such low districts, however, and in a climate modified by a surrounding sea, some portion of a previous flora might have been enabled to live on." By substituting the words "at a few feet below its present" for "at its lower Pleistocene," the passage reads in accordance with my ideas.

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

NOTICES OF MEMOIRS.

The Plant-World before the Appearance of Man.

M. LE COMTE DE SAPORTA has recently pointed out[1] that life was aquatic before it became amphibious, and amphibious before it became aerial, and that terrestrial life is but the latest expression of the sequence that took its initial point of departure in the ocean. The seas that deposited the Laurentian and Huronian rocks, 50,000 feet in thickness, contain only the Rhizopod *Eozoon*. The Cambrians of Britain and Sweden give but 50 species of primitive types, marine vegetables, a few Sponges, Corals, and Echinoderms, Brachiopods alone representing the Mollusca, which gradually spread from their first birthplace in the Polar Ocean to other basins, no cause formerly operating to limit their extension. In Silurian times Crustacea were alone represented by Trilobites, which occurred in profusion, disappearing suddenly in the Coal-measures, and the order is now only represented by *Limulus*. Similarly, at the close of the Secondary epoch, the Ammonites as suddenly cease to exist.

The most ancient terrestrial Vertebrates show traces of affinities with the Fishes on one side, and the Batrachians on the other, and the Reptilian affinities of *Archæopteryx* are commented on; the

[1] Le Monde des Plantes avant apparition de l'homme. Paris. J. Masson. 1879.

mandibles with teeth found in the American Chalk showing a bird less Reptilian than *Archæopteryx*.

The *Labyrinthodonts* of the Coal-measures were less highly organized than those of the Trias, the ossification of the vertebræ being imperfect, and the disposition of the teeth resembling that of fishes.

The Fern, *Eopteris Morièrei,* Saporta, discovered by Prof. Morière of Caen, is the oldest terrestrial plant known, being derived from the Ardoises of Angers. In the *Cincinnati group* of America, Lesquereux has recorded several vascular Cryptogams and Gymnosperms, a *Sigillaria* (*Protostigma sigillarioides*, Lesq.), Calamites (*Annularia Rœmingeri*, Lesq., and *Sphenophyllum primævum*, Lesq.).

Insects are present in the Devonian, and no less than 30 species occur in the Carboniferous according to Heer. A Myriapod, *Anthraceps*, recently discovered in Illinois, has similar breathing apparatus to that of the order at the present day.

The Scorpion of Bohemia differs but little from the venomous species of the tropics.

From the Infra-Lias of one locality (Argovie) M. Heer records no less than 143 species of insects. Beetles and leaf-eating forms abound; but Butterflies, Bees, Ants, and Flies are still absent.

In the second chapter the author gives a careful analysis of the theory of Evolution, especially as to the facts adduced by Mr. Darwin.

In Chap. III., on ancient climate, it is pointed out that:—

At the foot of the Himalaya, tropical vegetation is maintained up to 1000 mètres; at 2000 Palms and Bananas have disappeared, and are replaced by Oaks and Pines; at 3000 snow falls in winter; at 3500 occurs a zone of Cedars; at 5000 corn is still cultivated, at an elevation about that of the top of Mont Blanc; at 5500 all life disappears.

Since the "Golden Age" of the poets there has always been present a legend of successive changes undergone by the world.

In the Quaternary age M. de Saporta considers the climate was much more humid, and the rivers consequently larger, both in Europe, Asia, and Northern Africa.

He refers to the extension of the glaciers of the Alps not only to the Jura, but from the observations of M. A. Falsan almost to Lyons. He comments on the colossal proportions of the glaciers of Argeles in the Pyrenees worked out by MM. Martins et Collumb, and the former extension of the glaciers of Scandinavia and Spitzbergen, during which the shells of the Arctic Ocean lived in the British Seas, and the plants and mammals of the Far North occupied the plains of Europe. He points out that the species found in the low grounds—to which the excessive size of the glaciers might be supposed to drive both animals and plants—are associated with species indicating warm conditions; thus the mammals of the alluvia of the Seine and Somme, worked out by M. E. Lartet and by M. A. Gaudry, are associated with *Elephas antiquus* near to that of India, and shells of *Cyrena fluminalis*, while the Mosses tell the same story as regards the plants; Vines and Laurels occurring in great abundance, not only in the middle of France, but at Moret, near Paris, and he considers that the polar forms did not travel far from the glaciers themselves, and that the valleys enjoyed a more humid and temperate climate, and evidences the observations of Haast as to the descent of glaciers in a humid climate in New Zealand.

The mean annual heat of Lyons is now 11° Centigrade; in Quaternary times it was 14° to 15°; in Pliocene times it was 17° to 18°; the flora of the Canaries flourishing on the banks of the Saône.

The author lays great stress on the discoveries of Nordenskjöld, in Southern Spitzbergen, of plants of Carboniferous, Jurassic, Cretaceous, and Tertiary times, and states the labours of Professor Heer show the position of the earth's axis was the same in Tertiary times as at present. To Greenland he assigns a mean temperature of 9·7° Cent. in Miocene times, rising to 22° in Switzerland, the northern limit of Palms traversing the Rhine provinces and Belgium about the 50th parallel, while at the present time (excepting the *Chamærops humilis* at Nice) their limit is the 30th to the 35th parallel.

The Eocene era was marked by the multiplication and extension of Palms, Pandanas, Bananas, and other tropical plants in England and Germany, indicating a mean temperature of 25° Cent.

The Cretaceous flora of Bohemia (Cenomanian) is characterized by the first appearance of Dicotyledonous plants, including the genus *Credneria*, Magnolias, and Laurels; at Toulon, seven degrees further south, these are rare, and Conifers are the dominant forms, especially a fine *Araucaria*, and the author concludes that Dicotyledonous plants travelled from north to south, and that climate in this period first became differentiated. In Jurassic times the same vegetation spread from India, Siberia, and Spitzbergen to Europe.

The author considers in early times the earth was covered with thick fogs, the atmosphere being charged with a diffused light. With Buffon, he believes that life originated at the Poles, and travelled equatorially, and he comments on the fact that the chief Coal deposits occur at the polar sides of the equatorial zone, and that the still older *Eozoon* of the United States and Bohemia are similarly limited in area, and he regards the 50th parallel as the equator of the origin of life. An equal distribution of heat, probably not exceeding 25° or 30° Cent., prevailed throughout the world in the early periods, the contrasts of day and night, summer and winter, being but slightly marked; that light, though diffused, was certainly present, is proved by the existence of the reticulated eye of the Trilobite.

He considers the former tropical heat of the earth to be in no way connected with its central heat, nor does he ascribe the gradual secular cooling of the crust to have influenced the cessation of warm conditions on the surface—no signs of gradual decrease being apparent, as would have been the case, and especially no signs of intense heat, in the indication given by the earliest vegetation; and agrees with M. Burmeister that the earth's crust had so far solidified as to be a considerable thickness before life appeared on its surface, and points out the low conducting power of the rocks forming this crust.

In the second part, the author reviews in succession the Vegetable Periods, which he divides as follows:—

Geological Formations.	*Stages.*	*Phytological Epochs.*		*Phytological Periods.*
Primordial or Protozoic.	Laurentian. Cambrian. Silurian.	Primordial or Eophytic.		Primordial.
Palæozoic.	Devonian. Carboniferous. Permian.	Carboniferous or Palæophytic.		Devonian. Palæanthracitic. Carboniferous. Supracarboniferous. Permian.
Mesozoic or Secondary.	Triassic.	Bunter. Mushelkalk. Keuper.	Secondary or Mesophytic.	Triassic. Infraliassic.
	Jurassic.	Lias. Oolite.		Oolitic. Wealden.
	Cretaceous.	Neocomian. Chloritic Chalk.		Urgonian.
		Rouen Chalk. Upper Chalk.	Tertiary or Neophytic.	Cenomanian. Supracretaceous.
Neozoic or Tertiary.	Eocene. Miocene. Pliocene.			Palæocene. Eocene. Oligocene. Miocene. Pliocene.

In the first chapter of the second part the author reviews the vegetable contents of the various formations. The earliest traces are marine, the *Bilobites* (*Cruziana*) *rugosa*, D'Orb., being a true Algæ from the Silurian; *Harlania Hallii*, Gœpp., *Chondrites fructiculosus*, Gœpp., *Murchisonites* (*Oldhamia*) *Forbesi*, Gœpp., from the Irish Silurian, and *Spirophyton*, Hall, of America, belonging to the same category. He comments on the plants of the Lower Silurian being purely marine, and figures the oldest terrestrial plant, *Eopteris Morièrei*, Sap., discovered by Prof. Morière in the slates of Angers, in the zone of *Calymene Tristani* (base of Middle Silurian), a Fern near to *Cyclopteris* of the Coal-measures. In America M. Lesquereux, and in Canada Principal Dawson, have recognized *Sphenophyllum* from the Upper Silurian, the species being *S. primævum*, Lqx. Lesquereux has also described *Protostigma sigillarioides*, Lqx., and a Lycopodiaceous plant, *Psilophyton*, has been recognized by Dawson, with affinities leaning towards the Ferns through *Hymenophyllum*, with the Rhizocarps through *Pilularia*, with the Lycopods through *Psilotum*. *Psilophyton* also occurs in the Devonian of Canada, with *Asterophyllites*, *Annularia*, *Calomendendron*, *Lepidodendron*, and ferns.

Before describing the Coal-measure flora, the author notices the formation of modern peat-mosses, and points out the conditions necessary for their production, the most important being an equable temperature, constant humidity, a flat country allowing free access to water supported by an impermeable soil, and a moderate amount of heat, peat-mosses not growing south of the 40th parallel.

The Carboniferous period marks an epoch during which a large continental area was from time to time slightly submerged beneath the water, forming vast shallow lakes, whose shores were tenanted by dense masses of vascular Cryptogams and Phanerogamous Gymnosperms, under a thick atmosphere charged with vapours precipitating rain, with a violence now unknown, producing an equable damp and warm climate. The labours are summarized of Grand'Eury, Renault, Brongniart, of Corda, Gœppert, Geinitz, Goldenberg, Stur in Germany and Austria; Schimper of Strasbourg; Lesquereux, Dawson, Dana, in America; and Williamson and Binney in England.

The Permian flora exhibits transitional and ambiguous characters, the characteristic elements of the Carboniferous being absent—Cycads, Conifers, and some Ferns have the preponderance (*Walchia piniformis, Ginkgophyllum Grasseti*).

In the succeeding Mesophytic, or Secondary epoch, the Triassic flora marks a period of decadence of old types barely replaced by new forms—species and individuals being alike rare. The Conifers are represented by *Voltzia heterophylla*, Schimp., and *Albertia Braunii*, Schimp.; the Ferns by *Danæopsis Marantacea*, Hr., and *Tæniopteris superba*, Sap.

In the Jurassic epoch, though the Carboniferous types of plants are gone, the Angiosperms, which form nine-tenths of the existing flora, have not yet appeared, except some rare Monocotyledons. Cryptogams are represented by Ferns; Gymnosperms by Conifers and Cycads, ranging from the Arctic regions to Hindustan and Europe, from Greenland to Irkutsk. Cycads now live in the Tropics, Florida and Japan marking their northern limit. The Infra-Lias Ferns, *Clathropteris platyphylla*, Gœpp., *Thinfeldia rotundata*, Nath., and Cycads, *Podozamites distans*, Presl., *Pterophyllum Jægeri*, Brogn., and *Pterozamites comptus*, Schimp., indicate a damp and humid locality. Ferns also occur in the Corallian, Bathonian, and Kimmeridgian stages. Amongst the Conifers are some resembling the modern *Araucaria*, others the Cypress.

Europe, at the commencement of the Jurassic period, formed an archipelago of large islands; the central plain, at the end of the Lias, was still separated from the Vendée to the west, and from the Vosges and Alps to the north-east. These islands gradually coalescing formed one Continental mass, at the close of the Oolitic period, when lacustrine and fluviatile conditions set in, over a large part of England and North Germany, expressed by the Wealden, and Urgonian strata of Wernsdorf, in the Carpathians, which latter has much in common with the Greenland Cretaceous flora. Amongst the latter is the Cycad, *Pterophyllum concinnum*, Hr., and *Sequoia ambigua*, Hr.

The author comments on the circumstance that led to the appearance and rapid multiplication of Dicotyledons, at the commencement of the Cenomanian epoch. He describes the Dakota beds of America as ranging through Kansas, Arkansas, Nebraska, Minnesota, and the region of Missouri, up to the Rocky Mountains, and resting on the Trias. Of similar age are the freshwater bands, with plants, of the Quadersandstein of Bohemia; they occur also in Moravia, the Hartz, and some localities in Saxony, Westphalia, Scania, and the neighbourhood of Aix-la-Chapelle and Toulon, and in Disco and Noursoak in West Greenland.

The most southern locality is that of Beausset, near Toulon, including *Magnolia telonensis*, Sap., *Lomatopteris superstes*, Sap., *Araucaria Poucasi*, Sap.; but other Dicotyledonous genera are rare, and are numerically stronger in the German localities, between 49° and 51° N. lat., which present a mixture of tropical and boreal forms, the genus *Credneria* being an example of the first, *Hymenea* of the second (one of the latter group, *Ceratonia siliqua*, still lives on at Mentone). In the Dakota group, the *Crednerias* are represented by *Protophyllum multinervæ*, Lqx., and *Aspidiophyllum.* M. Lesquereux has also recognized Oaks, Ivy, Beech, Planes, and Chestnuts. The flora of the Middle Chalk (Cenomanian) marks the commencement of the fourth and last vegetable era the author recognizes, specialized by the appearance of Dicotyledons.

This group increases in importance in the succeeding Tertiary epoch. The Monocotyledons, which had gradually been decreasing in number and importance, also become somewhat more salient again, as conditions more favourable to vegetable life come in. Europe had still no winter, and though already to a certain extent continental, the Alps and Pyrennes were only represented by insignificant islets; lakes were scattered over much of the surface, and plants were imbedded in volcanic ashes.

In the Palæocene (Saporta, *Suessonien* d'Orbigny) the flora is little changed. It extends from the N.E. of Paris into Hainault and Liège; in the latter province it has yielded a rich flora at Gelinden, containing Laurels, Cinnamons, Oaks, Vines, and a species of *Thuites*, near to those of Japan, the flora of which resembles the facies to a certain extent. The European Palæocene flora has some affinities with the American lignitic flora, and also with the Greenland Tertiaries, especially that of Atanekerdluk.

The Eocene period was characterized by the existence of the Nummulitic sea, a larger Mediterranean extending from Asia Minor and Arabia to Western Europe, and from Africa to a Gulf including the London, Paris, and Belgian basins; it is present in Persia, India, and China, and forms the summit of the Alps, forming one of the vastest inland seas of geological history, tenanted by similar biological forms.

Washed up on the shores of the Brito-Belgian gulf were seeds of a *Nipa*, of an Indian type, near to that now flourishing on the banks of the Ganges. Near Paris, on the site of the 1867 Exhibition, at the Trocadéro, occurred Palms, Pines, Thujas, and a Dryandra (*Michelotti*), a type now characteristic of the Australian flora. A similar flora occurs in the collection formed by MM. Aymard and Vinay, at Puy, in Velay, including the now African genus *Phœnix* (*P. Aymardi*) allied to the modern Date. To this age belong the sandstones of Beauchamp, the limestones of St. Ouen, the gypsum of Montmartre, the plant beds of Sarthe (M. Crie), and the neighbourhood of Angers, the Isle of Wight, and the lignite of Skopau in Saxony.

The flora of Aix is somewhat newer; it occurs in an old lacustrine deposit, 20 kilomètres in length, by 15 in width; it exhibits a rich flora, made up partly of European elements, and partly of plants now become purely exotic—Palms, *Flabellaria Lamanonis,* near to those of China, *Dracænæ* near to the Dragon Trees of the Canaries, Bananas near to those of Abyssinia and Africa, with plants of Australian and Madagascan flora affinities. *Acacias* abounded, whose modern representative affords the favourite food of the Giraffe.

Amongst the flora is a *Magnolia* leaf, the corolla of a *Catalpa* near to a Chinese species. Magnificent corollas of *Bombax,* and a Fig, *Ficus venusta,* near to *F. pseudocarica,* Mig., of Upper Egypt. Associated with the tropical types are the temperate forms, Oaks, Beeches, Elms, Poplars, and other temperate forms; these, however, are of rare occurrence, and it is suggested that they lived well above the level of the ancient lake, and experienced a different climate to that prevailing in the lower valleys. The facies of this apparently more temperate flora is rather that now existing in Central Asia than in Northern Europe as regards the Birch and Elm, while the Oaks resemble those of Louisiana, the Poplars those of the Euphrates and River Jordan; and on the whole the flora appears to have resembled that of Central Africa, with some elements in that of Southern Asia and China—conditions which lasted on to the end of the Oligocene, which is, however, characterized by the gradual introduction of Miocene species. Amongst the new types that appeared in Europe were species of Conifers, *Chamœcyparis,* many Sequoias, Taxodium. Amongst the Palms the *Sabal Hæringiana, S. major,* and *Flabellaria latifolia;* amongst the *Myricas, Comptonia dryandræfolia,* Brogn., most of them plants of an American type requiring either the presence of water or of a humid atmosphere. These plants traversed Northern America, Europe and Asia, and are associated with Oaks, Elms, etc., replacing the plants with African affinities, whose modern representatives require a large precipitation of rain.

The author refers to the presence of tropical types, as Cycads, Ferns, and *Gleichenia,* in the Jurassic and Cretaceous deposits of the Arctic lands, and especially to the number of species and profusion of the genus *Sequoia,* the presence of *Glyptostrobus thuja;* and he comments on the absence of the more purely southern forms, as the Palms, Pandanas, and Dragon Trees. In the succeeding epoch, the Miocene, of the Arctic region, the larger number of species appear for the first time on a horizon about parallel with that of the European Oligocene, which received from the Arctic Ocean the Limes, Chestnuts, Willows, Cedars, Birches, just alluded to, which migrated over the whole of Europe, and occupied the whole of the temperate area. Elevation of Central Europe took place, and the sediment called *Flysch,* or "shales with Fucoids," was thrown down in saturated salt lakes resembling the Caspian and Sea of Aral. These Algæ become extinct in this deposit, though ranging up from the Palæozoic, and it is suggested that they were preserved unmodified in an inland salt sea. The Alps during this epoch probably formed a plateau, here and there covered by salt lakes; after a time the sea again gained on Europe; this *Tongrien* sea traversed a different direction to the older Nummulitic sea. It occupied anew the Paris basin, united the Isle of Wight, traversed Belgium, Westphalia, penetrated the Gulf of Cassel, fringed the Adriatic, and bordered the Vosges and the Black Forest. From the various localities including them in Alsace and Austria M. Schimper records no less than 800 to 900 species of plants. The general aspect of the vegetation resembles that now living in Australia. Palms (*Sabal major*) as large as the Parasol Palm of the Antilles. *Sequoias,* near to those of California. In the lake a profusion of Nymphacea and Nenuphars existed, now only found in Senegambia, Nubia, and Egypt. At Armissan, near Narbonne, the flora is specially rich, and exhibits characters transitional to the more modern Lower Miocene or Aquitanian.

The Oligocene period terminated with the retreat of the Tongrien Sea, which deposited the Fontainbleau grits, and at the commencement of the Miocene period the Paris basin emerged above the water, and the "Falun Sea" to the west was separated from the "Molasse Sea" of S.E. France by a central dry arm; the Faluns, of the Aquitanian period, mark deposits tranquilly deposited in lakes, gradually diminishing in depth; beds of the same age occur in the Baltic Amber region (54° lat.), at Bovey Tracey, Thorens in Savoy, Coumi in Greece (38° lat.), and Radoboj in Croatia, ranging through 16 degrees of latitude, though the included flora points to an almost absolute identity of climate. The Ferns point to a damp soil and climate. An *Osmunda* (*O. lignitum*) flourished near to the *O. presliana* of Southern Asia, Ceylon, Java, and Southern China. The genus *Lygodium* also now finds its most northern limit, with one species in Florida, and another in Japan, the Aquitanian forms most resembling the American species. The Palms (*Flabellaria* and *Sabal,* etc.) had not yet diminished in Europe. Sequoias still abound, but the Pines are becoming rarer, while the Oaks, Alders, Beeches, and Poplars commenced to exhibit their modern morphological characteristics. In the Baltic amber region Camphor Trees abound, but Palms are absent, but a number of the genus *Smilax* occur there. The limit of Palms passed probably a little north of Bovey Tracey to along the 52nd parallel. The *Sabal major* apparently did not pass north of Bonn, 50° 45′ W. lat., the lignites of which contain many other tropical plants, sensitive Mimosas, many Acacias, Azaleas, etc.

In the Coumi deposits temperate forms are few in species and individuals, and they are characterized by a profusion of tropical species. Palms are, however, rare; but the last Cycad that lingered in Europe occurs in it, the magnificent *Encephalartos Gorceixianus,* Sap., discovered by M. Gorceix.

Succeeding the Aquitanian lacustrine deposits come the Upper Miocene "Molasse Sea," the last that invaded our Continent, and turned Central Europe into a scattered archipelago. To the west the sea of the Faluns occupied the Garonne, but did not communicate with "the Molasse," which extended from Marseilles north-eastward by Lyons, the Jura, north of the Swiss Alps, to Bavaria, and occupied the whole of the valley of the Danube, the western shores of the Adriatic, Illyria, Thrace, and the S.W. of Greece, to which Prof. Heer has given the name *Pennino-carnienne*. The marine deposits at Carry, near Marseilles, being somewhat older than the inland Molasse beds, serve to show the gradual invasion of the Aquitanian land by the "Molasse Sea" took place from south to north. During this period the steps by which the temperate zone was becoming colder, though continuous, were softened by the heavy rains of summer and the mildness of winter, which still allowed a rich and varied vegetation. At no later period of the world's history did it contain so many species of Poplar, all sections of the group being represented in France, including many types driven southward by the cold, and only now found in North Africa and Southern Asia, as the variable-leaved Poplar, *Populus Euphratica*, which is the modern representative of *P. mutabilis* of Œningen; the former the author considers to be the plant referred to in the Psalm of Jeremiah, commencing, "By the rivers of Babylon," translated Willows, the Weeping Willows introduced from China being unknown in Hebrew times.

Remarking on the fact that for representatives of the Miocene flora we have often to turn to America, a successive immigration from the Pole southwards in all directions is suggested as the explanation of these ancient geographical connections. Amongst the Ferns (*Adiantum* and *Pteris*), we have several ancestors of existing Ferns. A *Salisburia* near to *S. adiantifolia* of Japan, *Sequoia*, *Taxodium*, and *Glyptostrobus*, occur among the Conifers. *Comptonias* in rich and elegant variety, now only represented by one form in the sandy marshes of Pennsylvania. The Green Oaks of Œningen reproduce the aspect of Mexico and Louisiana. Through the long summers of equal heat and mild winters, the genera *Laurus*, *Persea*, *Benzoni*, *Oreodaphne*, *Cinnamomum*, and *Camphora*, still lived in the centre of Europe, but in this epoch reached their final limit in this area. Again new types commenced to appear from the north, such as the Limes. An *Aralia* (*Panax circularis*, Hr.) still lived at Œningen, a Magnolia (*M. Ludwigi*, Ett.) at Salzhausen.

The author draws a striking picture of the number and variety of the vegetable forms, and the richness and elegance of the forests of the Molasse epoch, the locality of Œningen, near Schaffhausen, alone, having yielded to M. Heer no less than 475 species of plants, besides numerous Pachyderms, Birds, Reptiles, Fish, Mollusca, Crustacea, and Spiders, and 800 species of Insects. He considers that the climate must have resembled that of Madeira, Malaga, the South of Sicily and Japan, and Georgia, or indicates a mean temperature of 18° to 19° Cent. Broken branches and crushed leaves and flowers testify to violent storms and heavy rains; but the character of the vegetation shows that flowers and fruits persisted throughout the whole year. In these primeval forests lived the great Salamander (*Andrias Scheuchzeri*, Holl.), of which the living type is found in Japan (*H.*

japonicas, Tem.). Amongst other fossiliferous localities are the lignites of Wétéravic (Salzhausen, Roekenberg), Gunzbourg in Bavaria, Bilin in Bohemia, Menat in Auvergne, Mt. Charray in Ardèche, Parschlug and Gleichenberg in Styria, Tokay in Hungary, and the neighbourhood of Vienna.

Reviewing the Tertiary floras, the Count de Saporta points out the vigorous and complete flora of the Palæocene was succeeded by the poorer but more varied flora of the Eocene, containing an assemblage of plants with African and Southern affinities, which persisted on in the rich flora of the Miocene, in which, at the commencement of the Oligocene, an influx of Northern types is observable, which gradually increased in importance, as the influence of winter first appeared in Central Europe; the vegetable zenith was reached in this epoch, and with the succeeding Pliocene a gradual exodus of exotic forms took place, with the definite climatic change which is too marked to have been due simply to alteration of geographical configuration; though the elevation of the Molasse sea-bed into land and the appearance of the Alps probably snow-covered would not be without effect in assisting the general chilling of the atmosphere. But the change was a cosmical phenomena, commencing with the Oligocene, and embracing the earth in its effects. At the commencement of this era the ice at the pole would be sporadic and occasional, gradually becoming permanent, and to give off masses of floating ice to chill the more southern districts, themselves now covered with glaciers in the more mountainous parts. These changes were probably gradual. Resting on the marine Molasse, with *Ostrea crassissima* of Provence, are lacustrine deposits, in which tropical plants still linger. An exotic Fig, *Ficus Colloti*, Sap., and a Bamboo. At Cucuron, at the foot of Mont Léberon, M. Gaudry has discovered a large number of Mammals, and he observes the end of the Miocene is characterized by a great development of Herbivores; this is the case not only in Provence, but at Pikermi, in Greece, and Eppelsheim on the banks of the Rhine. Stags also began to appear. Oxen were still absent.

Mio-pliocene.—Arms of the sea still occupied the valleys of the Rhone, Danube, and the Po, and extended over parts of Belgium, north of the valley of the Thames, in Sicily and Algeria.

In the Vienna basin, resting on the Molasse, is the *Sarmatic* stage, with *Cerithium*, which contains a rich flora, near to that of Œningen. Cinnamons, Camphor Trees, Acacias, and *Sequoias*, and a *Callitris*, in the succeeding deposits, "the zone of *Congeria*,"—all these have disappeared for ever, except the genus *Sequoia*, and the Cinnamons, which still lingered in the floras of Stradella, near Pavia, and of Senigaglia, in the Marches; and in the East a true bamboo, *Phragmites*, still existed. The Sassafras of North America, the Glyptostrobus of China and Japan, the Planera, Platanus, Liquidambars of Southern Asia, are also still represented at Senigaglia; associated with Limes and Oaks, clearly the ancestors of our own European trees, and in beds of similar age (marine molasse of St. Fons, Isère), in the Rhone Valley occurs a Beech with entire curved leaves like that of our forests—*Fagus sylvatica pliocenica,* affording a valuable index of the existing climatal conditions, requiring, as it does, rain throughout the year.

In the somewhat newer fluviatile beds of Vaquières, explored by Prof. Marion, grew an *Alnus,* between a Syrian and a Japanese species; a *Glyptostrobus,* near to that of Canton; a reed, near to the green reed of the Nile (*Arundo Ægyptia antiqua,* Sap.), covered the sand banks of this ancient river. The calcareous deposits of Meximimiex, discovered by M. Falsan, disclose rich forests, resembling in the character of their vegetation those of the Canaries, joined with Asian, North American, and European facies; but tenanted yet, only by Stags, Mastodons and Tapirs.

To this age belong the lacustrine deposits associated with basaltic overflows of Auvergne; in that overlying the older lava M. B. Rames has found in Cantal the remains of *Dinotherium, Mastodon, Hipparion,* and *Machairodus,* which places these beds on the horizon of the Upper Miocene of Mont Léberon and Pikermi. Over these come porphyritic basalt, and trachytic conglomerate. The country was broken into ridges and escarpments, the northern and southern aspects of which were covered by a somewhat different vegetation, which also now varied with elevation,—profound forests occupying the hollows of great magnificence, and tenanted by a numerous fauna. New eruptions, first of trachyte, then basalt, then phonolites, then of more modern lavas. These are associated with volcanic tuff and ash beds, containing a numerous Pliocene flora, especially at Puy, in the "Grey marne with tripoli," at Ceyssac (Haute-Loire), examined by MM. Aymard and Haydes, and the Cantal beds examined by Rames, which he correlates with those of Lyons. At Pas de la Mongudo, on the south of the volcanic district, and Saint-Vincent, on the north, occurs a Japanese species of *Acer* (*A. polymorphum*), which has recently been reintroduced into France by the horticulturist. In these flora modern genera and species, Oaks, Elms, Alders, Poplars, etc., multiply in numbers, and preponderate over the few remaining exotic types. The same temperate facies is observable in the littoral deposits of the Val d'Arno, and in the travertines of Lipari, where the Palm, *Chamærops humilis,* still lingered on.

At the commencement of the Pliocene period, favoured by the dampness of the climate and the increasing cold, glaciers gradually descended the flanks of the high mountains to the valleys beneath, and great aqueous precipitation took place. The Norfolk Forest Bed is correlated with the horizon of St. Martial in Herault and the more recent parts of the Val d'Arno series. Mastodons had quitted Europe; Monkeys had emigrated to Africa; but Rhinoceri and Hippopotami had never been more numerous; Stags abounded; but the age was specially characterized by *Elephas meridionalis,* found associated in the sandy marls of Durfort, with the leaves—on which it fed chiefly—of an Oak, of a species still living in Southern Italy. A Laurel lived on in the Rhone Valley, and *Abies montana,* and other northern species, in the Forest Bed; climatal difference of vegetation in the North and South of Europe being first strongly accentuated in this period.

The author closes his work by summing up the seven elements into which the past and present French flora may be divided. The indigenous plants being those, like the Vine, that have never quitted France. Others, though fully developed in the Tertiaries, are now only tropical; others are cosmopolitan; some now live in foreign warm temperate regions, though extinct in France; others inhabit Madagascar and Africa; a small number have American affinities (Sabal Palms, etc.); whilst the Greenland and Arctic flora is well represented by Sequoias and Glyptostrobus of the French Tertiary.

C. E. De Rance.

REVIEWS.

I.—"Dr. W. Waagen On Geographical Distribution of Fossil Organisms in India." (Read at the Imperial Academy of Science, Vienna, December, 1877. Translated in Records Geol. Surv. India, vol. xi. p. 267.)

THIS paper, from the scope of its subject and the largeness of the conclusions put forward, may be called both important and ambitious. Important because, independently of the author's speculations, it contains a well-condensed summary of the geology of India as now known; and ambitious, in that it seeks to present somewhat of the changing scene of the ancient physical geography of this great portion of the earth's surface since early Palæozoic times. It speaks well for the progress of geological knowledge regarding India, that data of so tangible a nature exist to aid the impulse towards speculative inquiry.

No "fear to fall" would seem to prevent our author from climbing, and if we cannot quite go with him to heights within the region of pure conjecture, it must be admitted that his "bold" theoretical sketch wears an aspect of consistency so far as he adduces evidence, and, despite one's doubts of large assumptions, leaves the impression of being, at least to some extent, founded on fact.

The former existence of a continent of which India formed a part ever since Palæozoic times, is not by any means a new idea; this has been suggested or mentioned by many writers;[1] but the definition of its form at various geological periods, as indicated by the distribution of marine fossils, is the special object of the paper under notice; the author dissenting strongly from the supposition of Mr. H. F. Blanford, that this continent was connected with Africa or Australia.

After noticing all the formations of Peninsular-India, the Himalaya, Burmah, the Garrow hills, on the east, and the Suliman ranges to the west, and referring to his neat geological sketch-map, Dr. Waagen concludes from the distribution of "slaty" and sandstone Palæozoic rocks (the word 'slaty' being evidently used as synonymous with 'marine') that there was in Palæozoic times an Indian continent whose northern limits coincided with the foot of the Himalayan chain, and which included the whole of British India to the south.

[1] Hæckel, Hist. Creation. H. F. Blanford, Physical Geography of India, 1873. W. T. Blanford, J. A. Soc. Bengal, 1876. Geol. Mag. Decade II. Vol. III. etc.

During the most of the Mesozoic period the great outer crystalline zone of the Himalayas was a coast-range of this continent, and in Triassic times its northern boundary lay almost parallel to the Palæozoic coast-line, but between the outer and inner great crystalline zones, supposed to form the fundamental skeleton of those mountains.

In the Jurassic and Lower Cretaceous periods the continent had nearly the same outline to the north, though somewhat enlarged, its western limits coincided with the Suliman mountains, but the sea sent a great gulf up the Narbada (*Nerbudda*) valley for half its length, and also encroached upon the Madras coast from the mouth of the Godavery southwards to beyond Pondichery.

Upper Cretaceous times brought another change : the old central Himalayan coast-line in the longitude of Simla was moved somewhat further north, its eastward extension being uncertain. On the west the Suliman mountain regions were submerged, with the north-western part of the Punjab, the whole of Sind, Kach, and part of Kattywar. On the east a small area near Madras, the Sunderbans, Cachar, the south flanks of the Garrow hills, and the whole of Burmah, were under water, but the great peninsular area was mainly dry land.

In the Eocene period the sea spread over western India, and extended as far as the river Jumna. On the east its traces occur at the mouth of the Godavery, it reached up to the Garrow hills, and covered western Burmah.

Upper Tertiary marine deposits of Siwalik age are only known in southern Sind, and perhaps in Kach, hence the whole region was, it is presumed, at this time chiefly continental.

Except the Tertiary, all these changes in the outline of the land are shown by lines of different character on Dr. Waagen's map. And through all these eons the vast series of peninsular India's aqueous strata is declared to have been of inland fresh-water origin —a point already noticed, we may remark, by the late Dr. Oldham and Mr. W. T. Blanford [1]—but whether formed in basins or by rivers our author does not decide.

It is evident his reasoning upon this distribution of land and ocean throughout geological time is based upon known exposures of marine fossil-bearing rocks, but further discovery of marine beds of any age would modify the whole value of the conclusions, as would also any circumstance favouring the marine origin of strata as yet not known to contain fossils, and there are large deposits of this class in India.

Inspection of Dr. Waagen's map shows that nearly all his lines of limit of marine deposit converge at the N.W. corner of the empire ; this being also the only region in which he was employed even for a short season in the field, beyond a mere trip or so on one side or other of the Ganges valley, it may be fair to suppose that here the soundness of his conclusions can be tested. Let us glance at the evidence on which his reasoning is based in this country—one not altogether

[1] Pal. Ind. Series 4. 1. Records Geol. Surv. Ind. vol. iii.

undescribed,[1] though the most extensive memoir on the local geology by the Indian Survey (that on the Salt Range) has been for years awaiting publication, and has lain printed but unissued since the summer of 1877.

Dr. Waagen's Palæozoic continental shore-line edges the Salt Range escarpment, in which there occurs a group of beds said to have been prematurely referred to the Silurian age,[2] as well as a later development of generally-admitted (though the author uses the term 'so-called') Carboniferous strata. These marine groups are cut off by the escarpment on the south side of the range; the upper one reappears strongly on the Indus to the west, and it is evident the beds once extended further to the southward, hence there is absolutely no reason why they might not have reached as far as Delhi, or be even now buried beneath the great Sind-Punjab deserts. Here, at least, the author's conclusion as to continental limits must be founded on loose conjecture rather than on fact.

But in still earlier Palæozoic times an adjacent southern continent is better indicated amongst the older Salt Range strata, by the occurrence of derived crystalline boulders in an earthy matrix, of kinds unknown in the crystalline series to the north. The deposits are unfossiliferous, and their partly shore-like aspect or association with enormous layers of salt and gypsum are but slight reasons for asserting their marine, estuarine, or terrestrial origin. Consequently the presumed continental boundary in this direction at that early age becomes hazy if not totally obscure.

The supposed Palæozoic Attock slates, which occur further to the north, and comprise many sandstones and limestones as well, may be of course marine, though, in the absence of fossils, both this point and their exact age are quite incapable of proof; they are, nevertheless, included in Dr. Waagen's Palæozoic "slaty facies."

Nor can we find more satisfactory reason why the author supposes the outer Crystalline zone of the Himalayas to have formed the coast-range of a continent for most of the Mesozoic period; the only one he advances seems to be merely the absence of as yet recorded marine beds of this age along the south flanks of these mountains. The Himalayan crystalline rocks, however, are not the same as those of peninsular India, and he admits the possibility of their representing Palæozoic beds in a metamorphosed state. It is plain that a series of rocks, thus altered beyond recognition, might be of any age anterior to the Tertiary elevation of the range, and equally plain how slender and transparent is the assumption upon which the imaginary coast-line of a great ancient continent has been drawn.

Again, the author points out that his Triassic continental boundary line is visible in the Salt Range, but omits to say that the formation

[1] See papers by Fleming, Asiat. Soc. Bengal. Also Quart. Journ. Geol. Soc. London, 1874–78. Records Geol. Surv. Ind. vols. iii. vi. vii. viii. Memoirs Geol. Surv. Ind. vol. xi. and xiv. ("to be issued shortly.")

[2] Dr. Waagen himself, when in India, favoured this view, and never suggested its being doubtful, though the evidence was in his hands, in the shape of shells of an *Obolus*, determined as Silurian by the late Dr. Stoliczka.

with salt pseudo-morphs, seen in the eastern part of this range, and which he describes as replaced by marine beds to the west, is an entirely unfossiliferous group, whose Triassic age has no better foundation than a choice of guesses.

This being a special illustration of our author's system of coast-lines, we are bound to conclude that his most confident assumptions may be but visionary suggestions, the value of which depends largely upon unknown possibilities. And when some of these assumptions deal with a mass of formations so vast that the British Isles might be excavated vertically from within them twice over, or many larger countries made out of their materials, the whole being, on the negative evidence of absence of marine fossils, referred entirely to inland freshwater deposition, we may well pause before accepting in full the conclusions which the paper would establish.

Indulgence in such speculative flights as these has a dangerous tendency to encourage the charlatanism of a would-be "higher culture" in geology, when put forward with the arrogance of knowledge; and so far as the case before us is concerned, examination has but confirmed the doubts felt at first, as to whether we were really reading history or romance. W.

II.—The Physical Geology and Geography of Great Britain: a Manual of British Geology. By A. C. Ramsay, LL.D., F.R.S., etc., Director-General of the Geological Survey of the United Kingdom. With a Geological Map, printed in colours, and numerous Woodcuts. 5th edition. 8vo. pp. 639. (Stanford, London, 1878.)

NOT much more than ten years ago this excellent work first appeared as collected notes from the Professor's lectures on the Geological Structure of the British Isles, elucidating the operations of water, ice, and other natural agents in producing and modifying the surface of the earth in general, and of the British area in particular. By gradual increase of explanatory and illustrative matter the fourth edition had become twice as thick as the first, and proportionately valuable to the student desirous of recognizing and understanding all the characteristic features of mountain, moorland, and valley, sea, lake, and river, which interest, or ought to interest us both at home and abroad. The fifth edition, lately issued, has attained double the bulk of the last, by the introduction of thirteen chapters on the historical, successional, or stratigraphical geology of Britain. This portion has necessarily considerable value, possessing the interest which the teachings of so accomplished a geologist as the author must carry with them; but the palæontology is not equally well handled as the older portion of the work, in which the physics of geology are so well and plainly discussed, so perfectly illustrated, and so enthusiastically worked out with the results of the author's own researches and reasonings.

Those portions of the new chapters which treat of the physical geography and hydrography of each successive geological epoch will be useful to many readers, since they extend the results of what

Elie de Beaumont, Godwin-Austen, and others, well began, in applying definite geological observation to the discovery of the old shoals, shore-lines, and margins of the several great formations of strata. This is a subject of considerable interest in both practical and hypothetical aspects; and we trust that the life-long studies of Mr. Godwin-Austen will yet result in the atlas of palæogeography, towards the completion of which he had already done so much in 1862, when the Geological Society awarded him their Gold Medal in recognition of his sound and useful labours, particularly in working out the history of the geologic changes of land and sea in Western Europe.

This new edition of the Physical Geography and Geology of Britain is enriched with many new woodcuts, both of characteristic scenery, and of fossils belonging to the several formations. Furnished with these latter, and the description of the successive groups of strata, the new edition is now entitled "A Manual of British Geology," and will be found useful to many general readers as well as to schools and classes. T.R.J.

III.—On the Old Red Sandstone of Western Europe. By Archibald Geikie, LL.D., F.R.S., etc. (Part I.)

[From the Transactions of the Royal Society of Edinburgh, vol. xxviii. 1878.]

The recent papers in the Geological Magazine on the Devonian question, and on the relations of the Old Red Sandstone to the Silurian and Carboniferous rocks, especially those by Mr. Kinahan, Professor Hull, and Mr. Champernowne, have suggested new interpretations of these great rock-masses and some important revisions in their classification.

There is a tendency to split up and almost annihilate the Old Red Sandstone. Thus Mr. Kinahan has grouped the Irish representative as Carboniferous, placing the Dingle or Glengariff grits as Silurian; while both Professor Hull and Mr. Champernowne are inclined to regard portions of the Devonian rocks also as Silurian.

Professor Geikie's memoir on the Old Red Sandstone of Western Europe will therefore be read with particular interest by those who have paid any attention to the varieties of opinion on its equivalent deposits, and all geologists will hail its appearance as giving not merely a summary of what is known on the subject, but a large amount of original observation.

Commencing with an historical introduction, Professor Geikie tells of the first application of the term Old Red Sandstone, and how it came to be regarded as the lacustrine equivalent of the marine Devonian rocks, although, as he observes, "the alleged contemporaneity of these two groups of strata had, in England at least, been assumed rather than proved." Into this question, however, he does not enter, his object being to examine into the distribution and history of the deposits which admittedly belong to the Old Red Sandstone.

Discussing the value of the threefold division of Murchison, Professor Geikie says, "My own work in the centre and south of Scotland had proved the Old Red Sandstone to consist of two great divisions — a lower passing down conformably into the Upper Silurian shales, and an upper graduating upward into the Lower Carboniferous sandstones, with a complete discordance between the two series. Mr. Jukes and Mr. Du Noyer had made out a similar arrangement in the South-west of Ireland." And he adds, "The lithological argument seems to favour the classification adopted by Mr. Jukes, for a great part of his Dingle beds would answer well for much of the lower Old Red Sandstone."

Until we are able to study the succeeding parts of Professor Geikie's memoir, we must be content with quoting the above passage, which is significant when taken in conjunction with Mr. Kinahan's researches.

After a brief consideration of the condition of Western Europe previous to Old Red Sandstone times, Prof. Geikie passes on to the consideration of the Lower Old Red Sandstone, and its basins of deposit in the British area. These basins he limits to five, termed respectively, Lake Orcadie (including the whole of the Orkney Islands), Lake Caledonia, or the Mid-Scottish Basin, Lake Cheviot, the Welsh Lake, and Lake of Lorne (Argyllshire, etc.).

He observes, that in no part of its European distribution does the Old Red Sandstone attain the thickness and variety which it presents in Scotland. The present part of his memoir contains the account of the rocks in the area described as Lake Orcadie. It contains a table, showing the vertical range of the known fossils of the Old Red Sandstone of Caithness, compiled chiefly from data furnished by Mr. C. W. Peach; and a list of the fossil fishes of the Lower Old Red Sandstone of the North of Scotland. A folding-plate gives coloured sections of the strata of Shetland, Orkney, Caithness, Tarbat Ness, Culloden Moor, Gamrie, etc. H. B. W.

REPORTS AND PROCEEDINGS.

Geological Socifty of London.—I.—April 9, 1879.—Henry Clifton Sorby, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Geological Age of the Rocks of the Southern Highlands of Ireland, generally known as 'the Dingle Beds' and 'Glengariff Grits.'" By Prof. E. Hull, M.A., F.R.S., F.G.S.

After reviewing the opinions of previous writers with reference to the age of these beds, including those of Hamilton, Griffith, Murchison, Kelly, Jukes, and the Officers of the Survey, which showed that great uncertainty has hitherto prevailed, the author quoted a passage of the late Prof. Jukes, in which he confessedly left the determination of the age of these beds open for future examination; and he therefore determined to reinvestigate the question, bringing to bear upon it the knowledge which had since been acquired of other districts. For this purpose (and accompanied by Messrs. O'Kelly and M'Henry) he examined a series of sections, from the coast of Dingle southwards to Bantry Bay; and having also carefully examined the field-maps of the Survey of those districts, had arrived at the following results :—

First, that "the Dingle Beds" are perfectly conformable to, and continuous with, the Upper Silurian Beds of the Dingle promontory.

Secondly, that they are the representatives of "the Mweelrea Beds and Salrock Slates," of West Galway and Mayo, the age of which, as shown by the fossils, is Upper Silurian, and that "the Dingle Beds" may therefore be regarded as of the age of the Ludlow Rocks, but unusually developed. This view was adopted as far back as 1839 by Sir Richard Griffith.

Thirdly, that throughout the south of Ireland "the Dingle and Glengariff Beds" are disconnected from the succeeding conformable series, consisting of (*c*) Lower Carboniferous Slate; (*b*) The Upper Old Red Sandstone with *Anodonta Jukesii*; (*a*) The Lower Old Red Sandstones and Conglomerate; as these three conformable formations are found resting upon, and against, the Glengariff beds successively in a direction either from south to north, or from south-west to north-east, owing to a conformable overlap against the flanks of an old shelving shore formed of the Glengariff beds.

Fourthly, that at the close of the Upper Silurian period, and after the deposition of "the Dingle and Glengariff Beds," these strata were disturbed, upraised, and denuded, and were not again submerged till the commencement of the Old Red Sandstone (*a*), when they were successively overlain by the beds of that formation with the succeeding ones of the Lower Carboniferous period, probably including the Carboniferous Limestone in some places.

Lastly, that it was during this period of upheaval that, as the author believes, the marine Devonian Beds (Ilfracombe and Morte series) were deposited, which accounts for their absence in the Irish area, which was either a land surface or only partially submerged. To this part of the subject the author hoped to call the attention of the Society on a future occasion.

2. "On some Three-toed Footprints from the Triassic Conglomerate of South Wales." By W. J. Sollas, Esq., M.A., F.G.S.

The author described the discovery by Mr. T. H. Thomas of some three-toed footprints in the Triassic Conglomerate at Newton Nottage, South Wales. They were stated to resemble in their most important characters the footprints of some Ratite birds, such as the Emeu: and this fact, taken in connexion with the occurrence of Dinosaurian remains in the Magnesian Conglomerate of Bristol, led the author to attribute to them a Dinosaurian origin.

3. "On the Silurian District of Rhymney and Pen-y-lan, Cardiff." By W. J. Sollas, Esq., M.A., F.G.S.

The paper commences with a history of the previous observations on the district; a description of the geographical distribution, geological structure, and vertical succession of the Silurian rocks is next given. They comprise beds belonging to the Wenlock and Ludlow groups, and pass conformably upwards into the Old Red Sandstone. The district affords a good base for a measurement of the thickness of the Old Red Sandstone on the south of the South-Wales Coal-field. This was found to be a little over 4000 feet. The thinning out of the Old Red Sandstone and Silurian strata, together with the marked change which takes place correspondingly in the lithological characters of the latter formation on passing from the north to the south side of the coal-field were taken to indicate an approach to a shore-line. This shore-line belonged to land which, as shown by the great thickness of the Devonian beds, could not have extended far south. It corresponded to Mr. Etheridge's barrier between the Old Red Sandstone and Devonian seas. The sandstones with Old-Red characters, such as the Hangman Grit and the Pickwell-Down Sandstones, occurring in the Devonian formation, were deposited at intervals when this barrier was submerged to a greater depth than usual. The Cornstones were stated to thin out to the south along with the other sedimentary beds of the Old Red Sandstone, and were regarded as derived from the denudation of previously upheaved limestones, such as the Bala and Hirnant. The paper concluded with a description of the characters of the more interesting rocks and fossils.

II.—April 30, 1879.—Henry Clifton Sorby, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "A Contribution to the History of Mineral Veins." By John Arthur Phillips, Esq., F.G.S.

In this paper the author described the phenomena of the deposition of minerals from the water and steam of hot springs, as illustrated in the Californian region, referring especially to a great "sulphur bank" in Lake County, to the steamboat springs in the State of Nevada, and to the great Comstock lode. He noticed the formation of deposits of silica, both amorphous and crystalline, inclosing other minerals, especially cinnabar and gold, and in some cases forming true mineral veins. The crystalline silica formed contains liquid-cavities, and exhibits the usual characteristics of ordinary quartz. In the great Comstock lode, which is worked for gold and silver, the mines have now reached a considerable depth, some as much as 2660 feet. The water in these mines was always at a rather high temperature, but now in the deepest mines it issues at a temperature of 157° Fahr. It is estimated that at least 4,200,000 tons of water are now annually pumped from the workings; and the author discussed the probable source of this heat, which he was inclined to regard as a last trace of volcanic activity.

2. "*Vectisaurus valdensis*, a New Wealden Dinosaur." By J. W. Hulke, Esq., F.R.S., F.G.S.

The author described some fossil remains, obtained by him in Brixton Bay, Isle of Wight, in 1871, consisting of an ilium, several pre-sacral, and one post-sacral vertebra. He established the Dinosaurian nature of the animal represented by them, and offered proof of its distinctness from already-known forms. He proposes for it the name *Vectisaurus valdensis*, a name descriptive of the locality and formation in which the remains were found by him. The characters presented by the genus *Vectisaurus* were stated to be as follows:—Ilium with a long compressed ant-acetabular process, having its greatest transverse extent in a vertical plane, and strengthened by a strong ridge produced from the sacral crest. Vertebræ in anterior dorsal region having opisthocœlous centres, their lateral surfaces longitudinally concave, transversely gently convex, meeting below in a blunt keel.

3. "On the Cudgegong Diamond-field, New South Wales." By Norman Taylor, Esq., of the late Geological Survey of Victoria; communicated by R. Etheridge, Esq., Jun., F.G.S.

The author described in detail the various spots at which diamonds have been found in this locality. They occur in river-drift, associated with gold and other gems. The drifts in the district are at least six in number. The oldest is considered by the author to be Upper Miocene or Lower Pliocene; the next Middle Pliocene; others Upper Pliocene, Pleistocene, and Recent. Between the Middle and Upper Pliocene flows of basalt lava took place, which have sealed up much of the older drifts. Diamonds are found in the oldest drift and, probably by derivation from it, in the newer. Gold, metallic iron, wood, tin, brookite (?), iron-sand, quartz, tourmaline, garnet, pleonast, zircon, topaz, sapphire, ruby, and corundum are also found. The author then considers the question of whether the diamonds are derived from some of the igneous or sedimentary formations (from Upper Silurian to Mesozoic) which have contributed to the drift; and concludes, from a variety of reasons, that the diamonds have been formed *in situ* in the older drift.

4. "On the Occurrence of the Genus *Dithyrocaris* in the Lower Carboniferous, or Calciferous Sandstone Series of Scotland; and on that of a second species of *Anthrapalæmon* in these beds." By R. Etheridge, Esq., Jun., F.G.S.

The author, in the first place, referred to the extension of the range in time of the genus *Dithyrocaris*, by the discovery of numerous fragmentary remains of *D. testudineus*, Scouler, in the Calciferous Sandstone or Lower Carboniferous Series of the south of Scotland, about the horizon of the Wardie Shales near Edinburgh, and in the Cement-stone group of Roxburghshire.

A further and more complete description of *Anthrapalæmon Woodwardi*, Eth., jun., was then given, in which the characters of some of the appendages were more particularly alluded to, such as the eyes, inner and outer antennæ, and first pair of ciliate appendages, thus placing the stability of the species beyond a doubt.

The paper concluded with the description of a second species of *Anthrapalæmon*, from the Lower Carboniferous rocks of Roxburghshire, for which the author proposed the name of *A. Macconochii*, after the discoverer of the specimen. This remarkable species, of which the carapace is at present the only portion known, differs essentially in the characters of this part of the body from all the other described species of the genus.

CORRESPONDENCE.

THE TILL IN NEW ENGLAND.

Sir,—Recent explorations of Professor C. H. Hitchcock and the writer in the Geological Survey of New Hampshire show that the unmodified drift in that State consists commonly of two deposits, quite distinct from each other. These appear to correspond to the *lower till* and *upper till* of Scotland and Sweden, described in the second edition of Geikie's *Great Ice Age*.

The lower till of New Hampshire and other parts of New England is composed of boulders, gravel, sand, and clay, indiscriminately mingled together, without any traces of stratification such as is produced by currents of water. Most of its pebbles and boulders have their sides planed to flat surfaces, which often retain striæ. The detritus in which these are imbedded is usually clayey and dark or bluish in colour, its iron being in an imperfectly oxidized state. This deposit is also distinguished by its being very hard and compact, so as to require it to be loosened by a pick before it can be shovelled, which has gained for it among the common people the name of "hard pan." It is the lowest in our series of glacial deposits, and appears by all these features to be the ground-moraine of an ice-sheet. Its accumulation seems to have been by the gradual addition or lodgment of material upon its surface, as is shown by a kind of lamination, which is almost always noticeable in sections that have been for a short time exposed to the weather. The detritus, though filled with rock-fragments, is obscurely divided into flakes one-eighth to one-fourth of an inch thick, which lie in planes parallel to the surface.

The upper till is a confused mixture of boulders, gravel, and sand, but seldom contains any considerable proportion of clay. It usually shows no stratification of any kind. Its rock-fragments are mainly rough and sharply angular, showing no marks of attrition, and they are generally larger than those in the lower till. Blocks occur in both up to ten feet in diameter, and in the upper till have sometimes from twice to four times that size. The colour of the upper till is yellowish, its iron having been fully oxidized. This deposit is loose, and may be easily excavated. It seems probable from these characteristics that this was material contained in the ice-sheet, gathered into it in its passage over hills and mountains, and that at its final melting the upper till was dropped loosely upon the lower till, or ground-moraine, on which it lies, being separated at a definite line.

The lower till occurs in flattened or undulating sheets generally throughout New England. It also forms in some districts very remarkable oval hills, which are from a few hundred feet to a mile in length, with two-thirds as great width, while their height correspondingly varies from 25 to 200 feet. But whatever may be their size, they are singularly alike in form, having steep sides crowned by a gracefully rounded top, presenting a very smooth and regular contour. From their resemblance in shape to an elliptical convex lens, Professor Hitchcock has called them *lenticular hills.* The trend of their longer axis is always approximately parallel with the striæ marked upon the bed-rocks of the same region. These accumulations are scattered without any apparent order quite abundantly upon areas five to ten miles wide, and ten to twenty-five miles long. One of these areas includes Boston and its harbour, and extends five to fifteen miles on all sides of that city; while North-eastern Massachusetts and Southern New Hampshire have three belts of territory upon which these lenticular hills abound. These areas are separated by others of equal extent, which are entirely destitute of such accumulations of till, or show only occasionally one, quite typical and prominent, but isolated from all others of its kind.

These hills, like the valleys and the whole of New England, are overspread by the nearly universal mantle of the upper till, which is commonly between one and five feet in depth, but sometimes reaches to ten or twenty feet.

As this Magazine has formerly presented instructive comparisons of the superficial deposits in Great Britain and in America, I would like to inquire through its pages whether British geologists have noted accumulations of till like our lenticular hills.

Nashua, New Hampshire, *April* 14, 1879. Warren Upham.

THE GEOLOGICAL CONGRESS AT PARIS.

Sir,—I am requested by an eminent foreign geologist to make the following additions and corrections with regard to the article on the International Geological Congress signed "A. L.," which appeared in the Geological Magazine for this month.

The Committee on Nomenclature included Professor Dewalque of Liège as Secretary, Professor Hébert being its President. Since then, Professor Ferdinand Römer, of Breslau, has occupied the office of German representative.

Professor Hughes, of Cambridge, is entered as member of both Committees; this double appointment has been made since the Congress, and is contrary (as I am informed by the eminent geologist aforesaid) to the principles of the Congress. The complete absence of non-colonial Englishmen at the Congress was much discussed at the time, and the fact that a country like England should be unable to provide *two* geologists to join in the Universal Congress augurs but poorly for the success of the meeting at Bologna. F. G. S.

April 28*th*, 1879.

BEEKITE FROM THE PUNJAB, INDIA.

Sir,—In a paper read before the Geological Section of the British Association held at Cheltenham, in 1856, Mr. W. Pengelly brought to notice a very remarkable and somewhat unique form of chalcedony, found plentifully in Torbay among the Triassic conglomerates, to which the name of Beekite has been given from Dr. Beeke, a former Dean of Bristol, by whom they were first publicly noticed. These Beekites consist of calcareous nuclei in a more or less advanced stage of decomposition incrusted with a thin surface of chalcedony arranged in tubercles, varying in size from a pin's head to a pea. These tubercles are surrounded by several rings, and frequently the same ring invests two or more tubercles. Occasionally the inclosed organism, which is either a Zoophyte or Mollusc, is found entirely decomposed and resolved into a few pinches of dust, and all that remains is the peculiarly mottled shell of chalcedony. In this case the Beekite will float as easily as a blown egg. There is a very fine specimen of a floating Beekite to be seen in the Silica Group of the Horse Shoe Mineral Case in the Geological Museum in Jermyn Street. Mr. Pengelly is of opinion that this peculiar siliceous deposit is due to the decomposition of calcareous pebbles in Triassic conglomerate surrounded by water holding chalcedony in solution, which has been caught up and deposited on the organic nucleus, the more readily from its being in a state of decomposition. The tubercular appearance may easily be accounted for from the appearance presented by a mass of fermenting and bubbling yeast. Thus the Beekite presents us with a most interesting stereotyped record of the evanescent, visible, and mechanical process of fermentation. Up to the present, I believe the range of this peculiar deposit is supposed to be restricted to the shores of Torbay, Australia, and the banks of the Nerbudda River in India. Mr. Pengelly, in the paper above referred to, gave it as his opinion that Beekites were only to be expected in conglomeratic rock containing decomposing calcareous pebbles, and through which water charged with chalcedony passes.

I have in my possession a very perfect specimen of Beekite which I found some years ago while travelling in an out-of-the-way part of India. It was on the slopes of Mount Sakesur, a high isolated peak forming the western extremity of the Salt Range in the Sind Sagar Doab of the Punjab; a locality fraught with the utmost interest to a naturalist, and especially so to a geologist, exhibiting, as it does, at a glance, almost a vast panoramic view of nearly all the typical palæontological forms familiar to European geologists, ranging from gigantic specimens of Brachiopodous shells, such as *Spirifer, Strophomena* and *Productus,* steadily up through Jurassic and Oolitic forms to those of the Eocene and Nummulitic Limestone. It was in the face of a precipitous cliff midway up the slopes of Mount Sakesur that I found my specimen deeply imbedded in a block of massive sandstone which had fallen from the overhanging cliff, which in itself consisted of a compact arenaceous formation of a dark grey colour literally teeming with Palæozoic fossils, such as the *Productus, Spirifer, Rhynchonella, Lithostrotion basaltiforme,* Crinoids, etc.

The specimen consists of a fragment of *Productus* shell, very probably *Productus horridus*—the formation itself being possibly Permian Magnesian Limestone. It is coated over with a crust of Chalcedony possessing identically the same tubercular structure met with on the specimens from Devonshire. As far as is as yet known, the geographical range of Beekites is in a limited area. The discovery, therefore, of my specimen in the Punjab Salt Range may possibly possess some interest to the question of distribution, coupled also with the fact that it was discovered in compact sandstone, instead of conglomerate. I shall be most happy to forward the specimen for the inspection of any one interested in the matter.

H. W. Jamieson, Capt., F.R.G.S.,
Junior Army and Navy Club. Bengal Staff Corps.

NOTE ON MR. LEE'S SPECIMENS OF FOSSIL WOOD FROM GRIQUA LAND.

Sir,—The Lignite from Kimberly Mine, Claim 196, consists of stems, or branches converted into a brittle lignite, which still preserves the original size and form of the stems, and exhibits the internal structure peculiar to the Coniferæ. The wood cells have a single series of discs, as in the wood of the recent Pines.

The specimens from Kimberly Mine, Claim 165, are more altered, and approach the condition of our Palæozoic coal. The small portions which show structure (mother-coal) consist of fragments of Coniferous wood, exhibiting the disciferous wood tissue with the discs in single rows.

The slides from the coal of Heilbron, Vaal River, Free State, consist of wood cells, with discs in single or double and opposite rows, as in the recent Pines. W. Carruthers.

Botanical Department, British Museum.

GEOLOGY OF THE ISLE OF MAN.

Sir,—I examined in April, 1878, with Dr. Stolterfoth, of Chester, the Conglomerate of Langness in the Isle of Man, and can add my testimony to that of Mr. Morton (Geol. Mag., May, 1879), that Mr. Cumming was not mistaken in assigning them a position below the Carboniferous Limestone. Not only are they seen in the beach to dip under the Limestone, but the lower beds of the latter are themselves conglomeratic and interstratified with beds of red conglomerate, resembling those which occupy a large part of the promontory. Like Mr. Morton, I failed to find any limestone pebbles in the Conglomerates. A. Strahan.

Holywell, *May* 12, 1879.

[The following is a copy of a letter addressed to the Editor of the *Times*; published May 19th, 1879. Its contents are so important that we gladly take leave to reprint it in the Geological Magazine. —Edit. Geol. Mag.]

"Position of the Silurian Rocks in Herts.

"Sir,—In June, 1877, you did me the favour to insert in the *Times* the announcement and recognition by myself of the Devonian rocks in the deep boring at Messrs. Meux's Brewery, Tottenham-court-road, which there occurred below an abnormal condition of the Lower Greensand at the depth of 1,140ft. This announcement was at first received with doubt; nevertheless, the problem as to what was the nature of the Palæozoic rocks below London was there and then solved. Since then borings of greater diameter still have been put down in other parts of the London Basin for the same purpose.

"Two of the trials have been some time in progress by the New River Company—one at Turnford, near Cheshunt, and the other at Ware, near Hertford. Both these important borings and extensions were undertaken by the New River Company for the purpose of obtaining a larger supply of pure water from the Chalk, and for settling the question of the existence or non-existence of the Lower Greensand in Hertfordshire. To a considerable extent the desire and anticipation of the Company have been realized through large supplies from their deep penetrations into the Chalk, this being especially the case at the Turnford deep well, near Cheshunt.

"The presence, however, of the Lower Greensand below the Gault in Hertfordshire has long been problematical; but, knowing that usually it is a source of extremely pure water and in considerable quantities, the New River Company undertook, with great public spirit, the completion of the two deep borings named, through the Chalk and Gault. They were quite aware of the probability or possibility of finding some Palæozoic rock under their trials in Hertfordshire, and, unfortunately for the deeper supply of water, such has proved to be the case, owing to the absence of the Lower Greensand at Ware (one of their stations), and the occurrence of the partly anticipated more ancient rocks, upon which they now find the Gault immediately rests, without the intervention of the Lower Greensand.

"It is well known how much interest is attached to the question of the extension of the older formations under the overlying or newer rocks of the south-east of England; this interest is now intensified through the Ware boring by the discovery of one of the oldest formations in the British Islands immediately beneath the Gault and at the depth of 800ft. At this depth I have to announce the presence of the Upper Silurian rocks (the Wenlock Shale), richly fossiliferous, dipping at an angle of 40 deg., but to which point of the compass is not at present known. I believe this delicate matter will be ascertained by the engineers of the New River Company—a question of the utmost importance in determining the strike or bearing of the older *strata* at any depth. Fresh interest is now attached to the Turnford boring, the diamond crown being now low down in the Gault at 980ft.

"So spirited and costly an undertaking to seek for pure water for the supply of the metropolis is, indeed, highly judicious and important on the part of the New River Company. We must not too hastily complain of the want of public spirit, when every effort is made to obtain, even at great cost, an element so important to the sanitary condition of the people. In this the New River Company have not failed in intuition or purpose, and to their enterprise is due the solution of another geological problem.

"*May* 16. ROBERT ETHERIDGE."

NOTE.—Since the above letter was written to the *Times*, we have received from Mr. Etheridge the names of the fossils found in the cores of Wenlock rock at the bottom of the bore-hole at Ware. We hope to receive from him, for our next Number, a more detailed notice of the probable Physical Geography and extension of these old rocks underlying the Tertiary and Cretaceous strata of the London Basin. It is to be hoped that the direction of the "strike" may be determined in the course of a few weeks, a matter of paramount interest and importance to a true understanding of the distribution of the Palæozoic and other rocks, either here or underlying any other area where it has been determined they exist.

This is at present a problem of the first consideration in deep-boring, and upon its successful solution must depend in great measure the practical value of our knowledge that strata of high economic importance probably lie within an accessible depth beneath our feet. Until we know approximately the 'strike' of these Palæozoic rocks, it will be of little avail to suggest where next to *seek*, or in what direction we should test them by further experimental borings.

The following fossils have been determined by Mr. Etheridge from the few feet of cores examined:—

I. Protozoa.

1. *Ischadites Kœnigii*, Murch.

II. Echinodermata.

2. *Taxocrinus*, sp.

III. Annelida.

3. *Tentaculites ornatus*, Sby.

IV. Crustacea.

4. *Phacops caudatus*, Brünn.

V. Mollusca-Brachiopoda.

5. *Orthis canaliculata*, Lindst.
6. *Meristella tumida*, Dalm.
7. *Cyrtia exporrecta*, Dalm.
8. *Spirifera plicatella*, Linn.
9. *Athyris*, sp.
10. *Crania implicata*, Sby.
11. *Rhynchonella cuneata*, Dalm. ? or *deflexa*, Sby.
12. *Atrypa reticularis*, Linn.
13. *Pentamerus galeatus*, Dalm.
14. *Pentamerus linguifer*, Sby.
15. *Strophomena euglypha*, Dalm.
16. ——— *depressa*, Dalm.
17. ——— *rhomboidalis*, Wilckens.
18. ——— *antiquata*, Sby.
19. *Chonetes*, sp.
20. *Leptæna sericea*, Sby.
21. ——— *transversalis*, Dalm.
22. *Streptorhynchus*, sp.

Conchifera.

23. *Pterinæa*, sp.
24. *Mytilus mytilimeris*, *Conr.*
25. *Orthonota rigida*, Sby.

Gasteropoda.

26. *Euomphalus rugosus*, Sby.

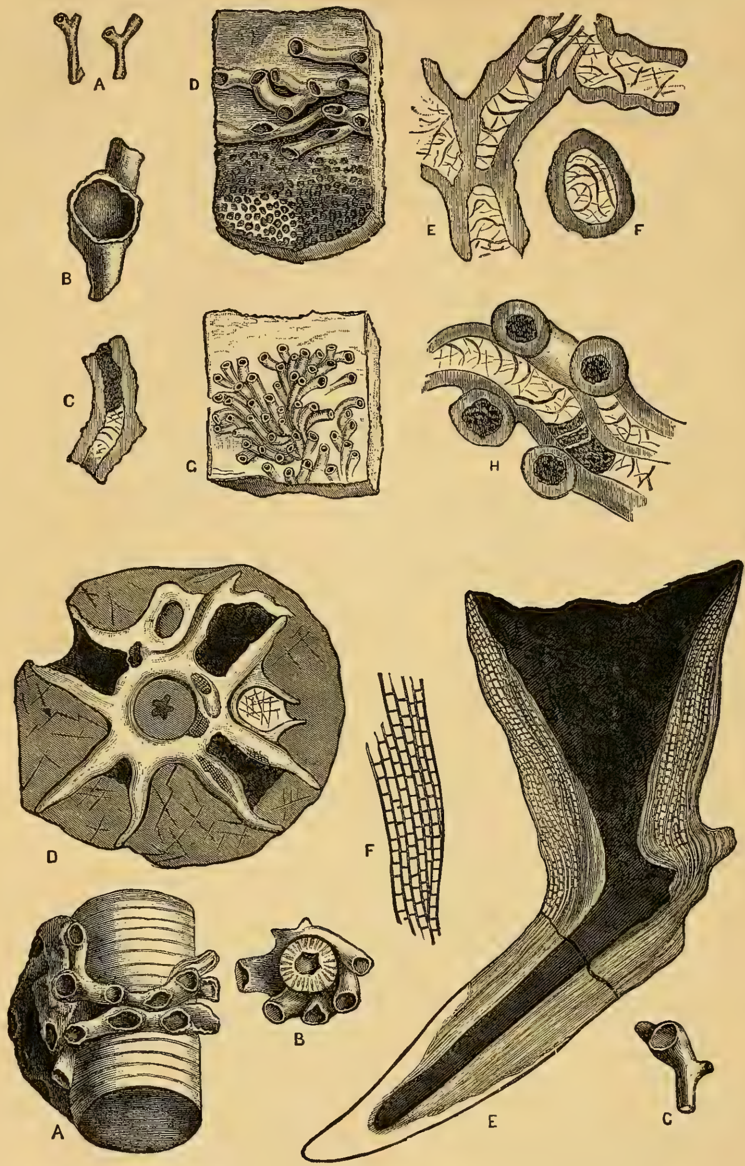
Cephalopoda.

27. *Orthoceras attenuatum*, Sby.
28. ——— sp.

OBITUARY.

Trenham Reeks, Died 5th May, 1879.

With much regret we record the death of Mr. Trenham Reeks, the esteemed Registrar of the Royal School of Mines, Jermyn Street. By his death one of the oldest associations of the Geological Survey and School of Mines is severed. When only about sixteen years of age, he became connected with the infant Museum established by the energy of his friend, Sir Henry de la Beche, in Craig's Court; and on the enlargement of that establishment, and the creation of the School of Mines, he was appointed to the office he has held until now; so that, although but 56 years of age, he had seen nearly 40 years of public service. Having worked at Chemistry and Mineralogy under Richard Phillips, F.R.S., he devoted himself to the enrichment of the Mineralogical collection under his charge in Jermyn Street. He also possessed great knowledge of pottery, and his illustrated handbook of the Ceramic collection is still a valued work of reference. Personally he was singularly courteous and obliging, and he so thoroughly identified himself with the interests of the School of Mines, that his loss to that Institution will long be felt.—("*Nature*," May 8.)



Cladochonus and Monilopora,

From the Carboniferous Limestone.

THE

GEOLOGICAL MAGAZINE.

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No. VII.—JULY, 1879.

ORIGINAL ARTICLES.

I.—On the Microscopic Structure of Three Species of the Genus *Cladochonus*, M'Coy.

By Prof. H. A. Nicholson, M.D., D.Sc., F.R.S.E., etc.;
and R. Etheridge, Jun., F.G.S.

(PLATE VII.)

1. *History.*—The genus *Cladochonus* was founded by Prof. M'Coy in 1847 (Annals Nat. Hist. vol. xx. p. 227) for certain Australian Palæozoic corals, with "some relation to *Aulopora*," but differing "in their curious erect habit, regular, angular mode of branching, slender, equal stem-like tubes, and abruptly dilated terminal cups bent in nearly opposite directions." Prof. M'Coy also lays stress upon the thickness of the walls in *Cladochonus*, and the proportionately small calices, and states (*loc. cit.*, and *Ibid.* 1849, vol. iii. p. 134) that the curious little corals formerly referred by him to Lamouroux's *Jania* will fall into this genus, viz. *Jania crassa*, and *Jania bacillaria* (Synop. Carb. Limestone Foss. Ireland, 1844, p. 197). The Australian species *Cladochonus tenuicollis* is distinguished by the slenderness of the stolons connecting the calices. In 1851 Messrs. Milne-Edwards and Haime described a genus under the name of *Pyrgia* (Polyp. Foss. Terr. Pal. p. 310), which has been placed by subsequent writers as a synonym of *Cladochonus*, and we think with good reason. To their genus they assign the following characters—the corallum is free, pedicellate, with a strong epitheca, very deep calices, and without traces of septal striæ, and they consider that it differs from *Aulopora* in its simple and free habit. Two species were described, *Pyrgia Michelini*, Ed. and H., and *P. Labechei*, Ed. and H. The *Janiæ* of M'Coy they reserve their opinion on, but *C. tenuicollis* of the same author is referred by them to the young of the genus *Syringopora* (*loc. cit.* p. 296). Similar views were expressed by them in their subsequent "Monograph of the British Fossil Corals" (pt. 3, Corals from the Perm. Form. and Mountain Limest. p. 164),[1] and they further describe their *Pyrgia Labechei* (*loc. cit.* p. 166). In 1849 Prof. M'Coy added to the species of *Cladochonus* by the description of a form from the Carboniferous Limestone of Derbyshire as *C. brevicollis* (Annals Nat. Hist. 1849, vol. iii. p. 128), which possesses a peculiar zigzag

[1] See also Hist. Nat. Corall. 1860, vol. iii. pp. 298 and 322.

corallum. This species was afterwards figured in the British Palæozoic Fossils (1851, fasc. i. p. 85, t. 3 B. f. 10), and two of the former species were redescribed, *C. bacillarius* and *C. crassus.* In the generic diagnosis preceding the descriptions of these species, M'Coy states that the "cup-shaped terminal chambers are marked within by more than twelve longitudinal striæ." With regard to *C. crassus* we are told that "the mode of attachment of the young is most usually by the early branches growing in a circle round a crinoidal stem."

So far as we are aware, Prof. John Morris, F.G.S., was the first palæontologist to unite the genera *Cladochonus*, M'Coy, and *Pyrgia*, Ed. and H., in 1854, in the second edition of his excellent Catalogue (p. 49).

In 1866 Herr Ludwig proposed the genus *Liodendrocyathus* (Palæontographica, vol. xiv. p. 213) for the reception of the well-known coral *Syringopora serpens* and a new species *L. tubæformis*; the latter is considered by Prof. de Koninck to be a *Cladochonus* (Nouvelles Recherches, 1872, p. 152), a supposition in which he is in all probability correct. We unite our protest with that of Prof. de Koninck against the unnecessary introduction of genera by Herr Ludwig for various Palæozoic corals, the generic affinities of which are quite well known. One of the most important discoveries yet made in the structure of *Cladochonus* was that by our friend Dr. H. Woodward, F.R.S., who, in 1869, drew the attention of the late Mr. John Rofe, F.G.S., to the microscopic structure of the calices (Geol. Mag. 1869, Vol. VI. pp. 352–53, Fig. 4 and 4*a*), which appear to have their walls minutely reticulate, not tabulate as Mr. Rofe supposed. The latter also entered at length into the peculiar habit, possessed by at least one species of *Cladochonus*, of attaching itself to the surface of Crinoidal stems, a fact first pointed out by Prof. M'Coy, but which was much more attentively studied by Mr. Rofe. We shall return to these points further on.

In 1872 Prof. L. G. de Koninck published a fresh description of *C. Michelini*, Ed. and H., and brought together a large mass of information concerning the genus generally. He defines the corallum as multiplying by lateral gemmation, furnished with a pedicle of attachment, very deep circular calices with feeble septa, and no tabulæ (Nouv. Recherches, 1872, p. 150).

The foregoing is, so far as we are acquainted with *Cladochonus*, a tolerably full outline of its history.

The following are the described species:—

Cladochonus bacillarius, M'Coy.
" *crassus* "
" *brevicollis* "
" *Michelini*, Ed. and H. (*Pyrgia*).
? " *Labechei* " "[1]
" *tubæformis*, Ludwig.
" *hians*, Eichwald.[2]
" *tenuicollis*, M'Coy

[1] We think it exceedingly probable that Prof. Morris and de Koninck are correct in referring this genus to *Cladochonus* with doubt (Cat. Brit. Foss., 2nd ed. p. 49, and Nouv. Rech., 1872, p. 152), and we also agree with the latter in omitting *Jania antiqua*, M'Coy, from the genus.

[2] Lethæa Rossica, t. 28, f. 11.

In our remarks which follow we first give some notes on the relation of *Cladochonus* to *Aulopora*, and we next describe the microscopic structure of one or two species, more particularly of *Cladochonus crassus*.

2. *Relations of Cladochonus* to *Aulopora*.—The general resemblance subsisting between *Cladochonus* and *Aulopora* is so close as to strike the most superficial observer, and this is particularly the case between the aberrant *C. crassus*, M'Coy, and the larger forms of the latter, the *habit* of the coral being in both cases the same. It would lead us too far, upon the present occasion, to enter at any length into the general structure and relations of *Aulopora*, nor are our investigations on this head as yet completed; but there are one or two points in this connexion to which we may with advantage draw attention. *Aulopora* has generally been believed to possess corallites with entirely open visceral chambers, no *tabulæ* being present; and in this has been placed the principal distinction between this genus and young colonies of *Syringopora*. We have, however, made microscopic sections of two forms of *Aulopora*, one, a large species from the Devonian deposits of Canada (Fig. 1, *d—f*), and the other the well-known *A. repens* of the Eifel Limestone (Fig. 1, *g, h*); and in both we find that the cavities of the tubes are crossed by strongly arched transverse partitions or tabulæ. The invagination of the tabulæ is not so conspicuous as in *Syringopora*, but cross-sections of the tubes present a very similar appearance to that seen in the latter genus; and it seems clear that the internal structure of *Aulopora* is essentially the same as that of young colonies of *Syringopora*. We are not, however, prepared to assert that tabulæ are present in *all* the species of *Aulopora*, nor can we enter here into the question of the relations between this genus and *Syringopora*.

Coming next to the relations between *Cladochonus* and *Aulopora*, we have figured (Fig. 1 *c*) a longitudinal section of what we believe to be a corallite of *Cladochonus Michelini*, Edw. and H., from the Carboniferous rocks of Scotland. It must be borne in mind, however, that though one may identify a given specimen as belonging to such a small *Cladochonus* as *C. Michelini*, it is really impossible to be certain that one has not in fact to deal with a detached corallite of *Aulopora*; and there must therefore always attach a certain doubt to such sections as Fig. 1 *c*. That this section is really one of *Cladochonus Michelini*, E. and H., we believe, because the specimen from which it was taken had all the external features of this species, and it also occurred with others also having the characters of this form (Fig. 1, *a* and *b*), and again because we know of no *Aulopora* in the Carboniferous rocks of Scotland, from the breaking up of which fragments of this nature could have been derived. Further than this, however, we cannot go. All, therefore, that can be said is, that we find, in this and in similar longitudinal sections, that the visceral chamber of the corallite is sometimes, though apparently not invariably, crossed by delicate curved tabulæ (Fig. 1 *c*). Sometimes we have failed to detect these partitions, and in any case they are always remote, and very delicate in structure; so that they may be chiefly recognizable by the fact that the surrounding matrix has penetrated into the visceral chamber to a certain depth, and that its lower limit is marked by a clean and regular curved line. So far, then, as the evidence at present before us goes, it would appear that the internal structure of *Cladochonus Michelini* is essentially the same as that of those species of *Aulopora* which we have submitted to microscopic examination. It seems to be "tabulate," and it does not, therefore, conform to the definition of the *Zoantharia tubulosa* given by Milne-Edwards and Haime.

On the other hand, *Cladochonus crassus*, M'Coy, exhibits an entirely different structure, unlike that of both *C. Michelini*, E. and H., and the species of *Aulopora* which we have here figured. We shall deal with the internal structure of this remarkable species at greater length hereafter (see Fig. 2); and we need only say now that the visceral chambers of its corallites appear to be entirely open and free from transverse partitions of any kind, while the wall is greatly thickened, and exhibits in parts a very exceptional and abnormal differentiation of its tissues, which entitles it to take rank as a distinct generic type.

Cladochonus Michelini, Edwards and Haime.

Pyrgia Michelini, Ed. and H., Polyp. Foss. Terr. Pal. 1851, p. 310, t. 17, f. 8, *a* & *b*.
" " Quenstedt, Handb. d. Petref. 1852, p. 638, t. 56, f. 18.
" " Milne Edwards, Hist. Nat. des Corall. 1860, vol. iii. p. 322.
" " Fromental, Introd. à l'étude des Polyp. Foss. 1861, p. 318.
Cladochonus Michelini, de Koninck, Nouv. Rech. sur les Anim. Foss. etc. 1872, p. 153, t. 15, f. 6, and 6 *a*.

Observations.—It is unnecessary for us to redescribe this species after the full and detailed notice of Prof. de Koninck, our object now being to make a few remarks on the microscopic structure of the corallum.

As before noted, there must remain some doubt as to the reference of any given specimen to this species, rather than to the detached corallite of an *Aulopora*. The specimens, however, which we have selected for sectioning appear to us, for the reasons before given, to be really referable to *C. Michelini*, E. and H., and they appear to correspond in their general structure with *Aulopora repens*. That is to say, they generally exhibit a tubular visceral chamber (Fig. 1, *c*) crossed by a few irregular curved tabulæ, but otherwise uninterrupted. In other specimens we can detect no traces, however, of transverse partitions. The walls of the corallites are solid throughout, and we have failed to find any evidence of the peculiar reticulate structure of the wall which characterises *C. crassus*, M'Coy.

Loc. and Horizon.—Catcraig Quarry, near Dunbar, in shale above the Skaleraw Limestone; Skaleraw Quarry, near Dunbar, similar horizon—Lower Carboniferous Limestone Series—Coll. Geological Survey of Scotland.

Collector.—Mr. James Bennie.

Cladochonus bacillarius, M'Coy ?

Jania bacillaria, M'Coy, Synop. Carb. Limestone Foss. Ireland, 1844, p. 197, t. 26, f. 11.
„ *bacularia*, M'Coy, Annals Nat. Hist. 1847, vol. xx. p. 227.
Cladochonus bacularius, M'Coy, Annals Nat. Hist. 1849, vol. iii. p. 134.
„ *bacillarius*, M'Coy, Brit. Pal. Foss. 1851, fasc. i. p. 84.
Jeunes Syringopores, Edwards and Haime, Polyp. Foss. Terr. Pal. 1851, p. 296.
Young Syringoporæ, Edwards and Haime, Mon. Brit. Foss. Corals, 1852, pt. 3, p. 164.
Cladochonus bacillaris, Morris, Cat. Brit. Foss. 1854, 2nd ed. p. 49.
Jeunes Syringopores, Milne Edwards, Hist. Nat. Corall. 1860, vol. iii. p. 298.

Observations.—The forms we refer to this species from the Scotch Carboniferous Series we have only seen in fragments, and would therefore simply make the reference provisionally. The chief points of specific importance appear to be slender, straight, cylindrical branches, with the short conical cups at the summits, if these points can be accepted as a means of separation when no differences can be detected in their internal structure. We fail to see how the two so-called species, the present and *C. Michelini*, can be kept apart, as they appear to be clearly different stages of growth, or varieties of a single species. They do not differ in their microscopic structure, and nothing but perfectly trivial external differences exist.

Loc. and Horizon.—Charleston, Fife—Lower Carboniferous Limestone Series—Coll. Geological Survey of Scotland.

Collector.—Mr. James Bennie.

Genus *Monilopora*, Nich. and Eth., jun., (*gen. nov.*)

Monilopora (*Cladochonus*) *crassa*, M'Coy, sp.

Jania crassa, M'Coy, Synop. Carb. Limestone Foss. Ireland, 1844, p. 197.
„ „ M'Coy, Annals Nat. Hist. 1847, vol. xx. p. 227.
Cladochonus crassus, M'Coy, „ 1849, vol. iii. p. 134.
„ „ „ Brit. Pal. Foss. 1851, fasc. i. p. 85.
Jeunes Syringopores ? Edwards and Haime, Polyp. Foss. Terr. Pal. 1851, p. 296.
Young Syringoporæ ? Edwards and Haime, Mon. Brit. Foss. Corals, 1852, pt. 3, p. 164.
Cladochonus crassus, Morris, Cat. Brit. Foss. 1854, 2nd ed. p. 49.
Jeunes Syringopores, Milne Edwards, Hist. Nat. Corall. 1860, vol. iii. p. 298.
Cladochonus crassus, Rofe, Geol. Mag. 1869, Vol. VI. p. 352, Figs. 2, 3, 4 and 4*a*.

Observations. — *Monilopora crassa*, M'Coy, sp., may be distinguished from the other corals with which it has been usually associated by its large size, and by its thick, conical, short branches. Prof. M'Coy states that "the mode of attachment of the young is most usually by the early branches growing in a circle round a crinoidal stem," and a figure of this was given in his early work. There is, however, more than mere attachment when young, because the coral goes on growing and growing, until at last what with the increase of the parasite, and the deposition of matter by the crinoid about that portion of its stem infested by the coral, an excrescence of no small size is formed. The habit thus possessed by *M. crassa* has been referred to more in detail by the late Mr. Rofe, who has published figures illustrating the manner in which the coral attached itself permanently to the columns of crinoids. The subject has also been entered on at some length by one of the present writers, in a paper lately read before the Natural History Society of Glasgow. The Geological Collection of the British Museum contains a number of specimens of Carboniferous Crinoid stems singularly contorted and gnarled by the growth of *Monilopora* (*Cladochonus*) *crassa* and the subsequent efforts of the Crinoid to envelope its parasite. These are contained in the collections of the late Messrs. Gilbertson and Rofe. In almost every case the corallum is more or less entirely enclosed in the substance of the crinoid stem, and those with the corallites projecting for any distance from its periphery are exceedingly uncommon. This has been explained by Mr. Rofe on the supposition, that those not enveloped escaped simply because of the death of the crinoid before complete enlargement of the column had taken place. The usual external appearance presented by the combined crinoid stem and its encircling parasite is that of a swollen, or contorted stem, with a ring of circular apertures, sometimes with projecting lips, at other times on a level with the surface of the stem, or even with the substance of the latter closing over them. This last is much the most common condition, but occasionally we meet with two or more rings one under the other, and instances are before us in which successive growths have taken place so rapidly as almost to obliterate all trace of the original crinoid stem. Of specimens with the calices partially free, Mr. Rofe has figured a good example; of those with the mouths only showing in a single circle round the crinoid stem we give an example, and another where two circlets are preserved, and a third illustrating the confused condition produced by continued growth. In only one specimen have we been enabled to detect any trace of septa—and then only in the form of indistinct flutings in the interior of one of the calices. It should, however, be remarked that the specimens which have come under our observation have not been in the best state of preservation for the retention of delicate septal markings.

As regards the mode of growth of *Monilopora crassa*, the usual method adopted by the coral consists in the encircling of a crinoid stem by a single ring of corallites, the connecting stolons being applied directly to the surface of the crinoid stem, and the corallites thrown off from this at intervals and projecting outwards at a more or less oblique angle to the stem to which they are attached; while occasionally they project nearly at right angles. On this simple structure successive growths take place until a more or less confused aggregation of corallites results.

The very curious microscopic structure of the corallum in *M. crassa* was, so far as we know, first pointed out by Mr. Rofe (Geol. Mag. 1869, Vol. VI. p. 352, Figs. 4, 4*a*), though we are of opinion, as previously stated, that his conclusion as to its real significance was founded upon a misapprehension. He pointed out that there existed in the corallum of this form a singular reticulated structure, which he regarded as showing that the coral was "tabulate," and he figured this structure in the paper just referred to. Our own microscopical sections of *M. crassa* have entirely confirmed Mr. Rofe's discovery of this reticulated tissue, but have failed to demonstrate its existence elsewhere than in the substance of the *walls* of the corallites. So far as our observations go, we find the visceral chamber of the corallites of *M. crassa* to be entirely open and free from tabulæ, being usually filled with matrix from end to end (Fig. 2*e*). This being the case, *M. crassa* clearly conforms to the definition of the *Zoantharia tubulosa* laid down by Milne-Edwards and Haime, and cannot be regarded as a member of the old group of the "*Tabulata.*" In this respect, also, it differs from *C. Michelini*, as well as from those examples of *Aulopora*, which we have been able to examine by means of thin sections. Moreover, its structure is quite peculiar, and so far as we know, such as does not occur in any known coral except the present. The wall (Fig. 2*e*) is extremely thick, and for the most part exhibits a distinctly fibrillated structure, as if composed of successive concentric layers, this structure being equally conspicuous in longitudinal and transverse sections. In parts of the corallum, however, the concentric lamellæ of the wall become separated from one another so as to include a series of distinct interspaces or cavities, which are approximately parallel to the axis of the visceral chamber, and which are crossed at right angles by numerous delicate cross-bars or trabeculæ of sclerenchyma (Fig. 2, *e* and *f*). This singular reticulate or cellular tissue seems to be sometimes partially developed in the basal portions of the corallum (see Fig. 2, *d*), but is essentially and principally, if not altogether, present in that portion of the wall which forms the actual cup of each corallite. As before said, we have entirely failed to discover any traces of this cellular tissue as encroaching upon the true visceral chamber; and there thus arises a discrepancy between our observations and those made by Mr. Rofe (*loc. cit.*). This, however, may admit of explanation if we suppose that the longitudinal section figured by Mr. Rofe has really been *excentric*, and that instead of passing along the axis of the visceral chamber, it has really traversed the thickness of the wall. We are at present unable to parallel the peculiar structure of *C. crassus*, as above described, with that of any other coral known to us, nor can we offer any opinion as to the precise functions or homologies of the cellular tissue of the calicine walls.

Loc. and Horizon.—Carboniferous Limestone of Derbyshire and Lancashire; Gilbertson and Rofe Collections, British Museum.

So far, therefore, as our preliminary examination of certain species of *Cladochonus* has gone, it would appear that the genus as originally constituted contained corals of very different structure, judging by the conformation of *C. Michelini*, and *C. crassus*. The latter has a special structure of its own, quite distinct from *C. Michelini*, as well as from *Aulopora*, and for it we have ventured to propose the generic name *Monilopora*.

In conclusion, we have to express our thanks to Professor Geikie, F.R.S., for the use of specimens contained in the Collection of the Geological Survey of Scotland.

EXPLANATION OF PLATE VII.

FIG 1.—*a.* Two examples of *Cladochonus (Aulopora ?) Michelini*, E. and H., of the natural size, Lower Carboniferous, Dunbar.

b. A small example of the same enlarged five times.

c. A longitudinal section supposed to be of the same species, enlarged five times.

d. Portion of a colony of *Aulopora* sp., from the Devonian of Ontario, of the natural size.

e. Longitudinal section of part of the same, enlarged five times.

f. Cross-section of a corallite of the same, similarly enlarged, showing the tabulæ.

g. Portion of a colony of *Aulopora repens*, E and H., from the Eifel, of the nat. size.

h. Section of the same, enlarged seven times, showing curved tabulæ.

FIG. 2.—*a.* A full-grown colony of *Monilopora crassa*, M'Coy, growing upon the stem of a crinoid, of the natural size.

b. A younger colony of the same, encircling a crinoidal column, and viewed from above, of the natural size.

c. A detached fragment of the corallum of the same, of the natural size.

d. Transverse section of a young colony of the same growing upon a crinoidal column, magnified $2\frac{1}{2}$ diameters (the visceral cavities of the corallites are more or less largely filled with matrix, and the peculiar reticulated structure of the skeleton is here and there visible in the wall, while the whole has been finally enveloped by the growth of the stem of the crinoid).

e. Longitudinal section of a single corallite of the same, enlarged five diameters, showing the open visceral chamber, the fibrous wall, and the reticulated structure of the wall of the calice.

f. A portion of the reticulated tissue still further enlarged.

All the specimens are from the Carboniferous Limestone of Lancashire. (British Museum.)

II.—How the Appearance of a Fault may be Produced without Fracture.

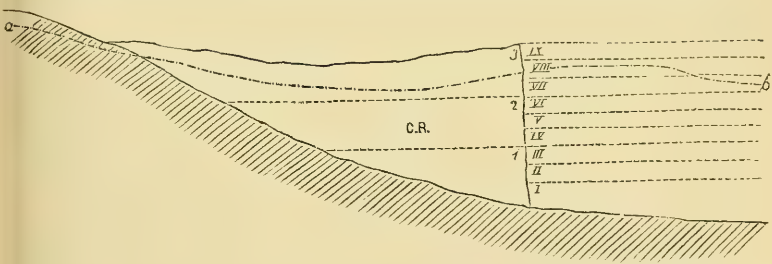
By W. O. Crosby, S.B.

THE general structure and mode of growth of coral reefs and islands is well understood; but there is one attendant circumstance of considerable geological interest, to which, so far as I am aware, attention has never been called. This is the peculiar stratigraphic relation of the different strata in the reef to their chronological equivalents in the deposits of the surrounding ocean; a relation due to the comparatively rapid growth of the reef as a whole.

Deposits of some sort, it may be safely said, are forming in all parts of the sea, of coarse materials and with comparative rapidity in shallow portions adjacent to the land, and of finer sediments and with extreme slowness in the oceanic abysses remote from the continental borders. Calcareous sediments usually accumulate much more slowly than those of mechanical origin, but to this statement the limestones of coral reefs probably constitute an important exception; while the growth of the reef under favourable circumstances is incomparably more rapid than the vertical increase of the impalpably fine, and mainly organic, ooze and mud covering the greater part of the ocean floor. This is proved by the fact that the coral reef and island are usually able to keep pace during countless ages with the progressive subsidence of the sea-bottom, so that their living growing crests are always within reach of the sunlight and air, while the dead and consolidated mass below stands like a wall towering thousands of feet above the slowly increasing and yet strictly synchronous deposits of the surrounding ocean, which appear to maintain their fineness and uniformity up to the very base of the reef.

The numerous soundings made in the vicinity of reefs have shown that their outer slopes are usually very steep and abrupt, often nearly vertical, and in some cases probably overhanging. Although undoubtedly extremely ragged and cavernous, at all depths below one hundred, or at the most two hundred, feet, these slopes are beyond the influence of the waves; and in consequence are not subject to decay, except as the calcareous matter may be slowly attacked by the carbon dioxide so abundant in sea-water at great depths.

Of course when the formation of a reef first begins, it is on the same level with the differently and more slowly formed but synchronous sediments of the adjacent portions of the ocean-bed; as its growth continues, however, it rises wall-like above these, and synchronous layers in the two sorts of deposits, always differing in thickness, are no longer stratigraphically continuous, those in the reef lying at higher levels than those outside. And with the lapse of time the vertical separation of beds of the same age must become greater and greater; so that if we may assume that the reef grows three feet (a low estimate) while the surrounding deposit is rising one foot, then when the former has attained a height of three thousand feet, the latter will be only one thousand feet thick, and the last-formed beds on either side will be separated vertically by two thousand feet. Supposing now that the subsidence, and, as a necessary consequence, the growth of the reef cease, then the gradual silting up of the outside ocean will continue as before, and in the course of time we will have, theoretically at least, lying on the same level with the upper part of the reef formations of a much later age, as shown in the diagram, where the horizontal bands within and without the reef are to be synchronized according to the numbers.



C.R.=Coral-Reef.

The reef is elevated to form dry land, and subsequent erosion developes the surface *a b*. Thus there is produced the general appearance of a fault, but without a fracture; and it is easy to conceive how a geologist might be deceived and led to conclude that the old coralline limestone of the reef had reached its present stratigraphic position through the agency of a fault.

In this pseudo-fault, it will be observed, the vertical displacement gradually diminishes downwards, becoming zero at the bottom of the reef; and many true faults, geologists are agreed, must die out below the surface in a manner equally gradual. Of course observation of the actual contact would probably undeceive the careful student, as the merely seeming fault would bear little resemblance, on close examination, to a *bona fide* fracture; but it is necessary to remember that our knowledge of the existence of faults usually rests upon more or less probable inference rather than direct observation.

Many coralline limestone formations are regarded by geologists as ancient reefs, and other limestones more compact may very well have had this origin, for it is well known that on modern reefs much of the rock formed only yesterday, as it were, is exceedingly compact and almost destitute of recognizable organic remains. My knowledge of the stratigraphy of our old reef limestones is too imperfect to enable me to determine whether their relation to the bordering formations is often such as I have sketched above, but it seems very improbable that this relation should not exist in some cases.

III.—The Slow Secular Rise or Fall of Continental Masses.

By Karl Pettersen, Tromso.

JOINING a foreign geologist, who was staying here a while last summer on his journey to the North, I followed the old shore-line or sea-level of Bredviken, cut in the solid rock, and extending along the north part of the island of Tromso, near the sound bearing the same name. When, at the end of that line, about Oerendalen, we threw a glance at the low ground beneath, named Skatoeren, this appeared furrowed with a series of natural ditches, stretched horizontally and parallel to the present coast. Seen from above, they were marked very sharply and distinctly. This attracted my attention, the more so as I had often been there, and as frequently traversed the plain, without having discovered the fact. We accordingly went down on the low ground to examine the matter more closely, but it did not appear there so distinctly, as might be supposed when seen from above. But after a more searching examination, we succeeded in detecting a series of more or less distinct and parallel furrows. Our time being limited, however, we could make no closer inquiry for the moment; but as I considered the matter worth more minute studying, I returned to the place a few days afterwards.

I did not see furrows this time from above as distinctly as last, owing to a less favourable light, and on the plain itself I now found it very difficult to trace every single furrow. The only way to do so was to fix your eye from above upon a single furrow, then walk down to it, and follow its course across the plain.

The flat low ground at Skatoeren is, it seems, composed altogether of remains of shells, mixed with sand. It ascends gradually from the present shore for nearly 120 mètres up to a height of about 10 mètres, thus forming the base of a row of hills that rise from its upper side. The plain has, it is evident, extended a great deal farther north. In course of time great washings and slips have taken place in that direction, and thus the plain in our day ends in a steep bank, consisting completely of shell-sand. The subsoil of the lowland, which consists of shells and sand, is overgrown on the surface with moss, which mossy cover is intersected crosswise with furrows, caused by the water purling down from above. At the first glance the surface appears as an infinite number of molehills, cut separately, and spread irregularly all over the plain. By this constant digging out, the original furrows, notwithstanding their distinct and regular course, when seen from above, have been effaced to the view so much, that you have some difficulty in discerning most of them when you walk across the plain.

From the sea upwards you will meet, at first, four successive furrows, at a distance from one another of about 3 mètres. From the fourth one there is an interval of 13 mètres to the next, that has been traced. This furrow is very distinct, and may be pursued longitudinally for 70 mètres. Above this one I have found still eight more furrows at different intervals, the highest of which lies about 8 mètres above the surface of the sea. It is very probable, however, that there are many furrows besides the above mentioned that have not yet been traced, or have perhaps been effaced.

When seen from above at least, the furrows appeared, however, close to each other, and seemed to follow each other at more regular distances.

There can be no doubt, it seems, that these furrows have been formed by the surf. Where our shores are made of fine sand or crushed shells, you will frequently find one or even several successive ridges, like walls, running parallel to the beach, caused by the lashing of the waves, that heap the sand in long drifts, lying in one level.

The uppermost of those lines on our present coast generally indicates the highest spring tide.

When seen from above, there is a striking likeness between the before-mentioned furrows and the ridges on the present beach.

With regard to our Arctic regions, it has already been proved some time ago, that the rise of the land, for the last 10 to 12 mètres at least, must have been effected slowly and evenly. Those proofs may be found in the frequently appearing banks of shell, that rise, in some places without interruption, from the present shore up to a height of about 10 mètres.

What we have said about the furrows at Skatoeren seems to prove, still more decidedly, that the rise has gone on by degrees and uniformly. Such perfect preservation of a series of successive shore-lines or margins admits of no supposition of a violent or sudden change of level.

As to the question of the secular rise or fall of the continent, relatively to the level of the sea, it has been considered long ago a scientific fact amongst most geologists, that during this change the surface of the sea has been, on the whole, unchangeable. John Playfair was, it is well known, the first who held this in his "*Illustrations of the Huttonian Theory*," published 1802. In that work he even mentions the slow rise of Sweden. Quite independent of that book, Leopold v. Buch comes to the same result. In his publication of 1810, "*Journey through Norway and Lapland*," he accentuates the fact—while mentioning the rise of land around the Gulf of Bothnia —in the following words: "*Gewiss ist es, dass der Meeresspiegel nicht sinken kann; das erlaubt das Gleichgewicht der Meere schechterdings nicht.*"[1] Supposing the centre of gravity of the earth to occupy always its original place, and that the quantity of the water spread over the globe remains, on the whole, unaltered, the doctrine of Buch is indisputable. Meanwhile, none of these suppositions can be considered quite certain. To answer the question with perfect surety, there is as yet too great deficiency in the materials of research. It has been tried, therefore, very often indeed, to shake the supposition of an absolute stability in the level of the sea. There has been no intention hereby of course to refer any alteration in the surface of the sea that bears no distinct local character, to the variability of the average level. It is evident, too, that a long series of risings or sinkings—throughout the different geological periods—must be regarded as an uprising or subsiding movement of the solid rock. Amongst other writers, James Croll has narrowly discussed the question in his book, "*Climate and Time in their Geological Relations*," 1877. He supposes the change in the level of the sea to arise partly from a displacement of the centre of gravity of the earth, caused by the spreading of an enormous ice-sheet over one of the polar basins, and partly by the solidification of so comparatively great a mass of water, as a consequence thereof. In fact, the continental masses of the Northern hemisphere seem, on the whole, to have risen throughout the Quaternary period, while in the Southern hemisphere they have sunk. The Antarctic basin being at present covered with ice on a large scale, this seems to coincide very well with Mr. Croll's supposition. Suppose the ice-sheet constantly increasing here, the tracts of land all over the Northern hemisphere must be rising continually in proportion, which is no doubt the case with large tracts. If this rise of the land had appeared quite regular, there would have been weighty reasons indeed to lean to the said theory. But, according to what has hitherto been observed relative to the rising and sinking of the ground at different places within the Northern and Southern hemispheres, not a few deviations have presented themselves, which do not coincide with Mr. Croll's doctrine. As to the east part of North America for instance, Prof. Dana has proved, that the observations made there do not tend to support that opinion. Furthermore, it has been considered a fact that a great part of the west of Greenland is at present sinking. Even some parts of England, Normandy, and the coasts of the North Sea, etc., are believed to be, or to have been, sinking; while, supposing that theory to be right, and that the changes in the level of the water are to refer altogether to it—all those regions ought, on the contrary, to have been rising constantly, and in the same proportion as Scandinavia.

Similar irregularities are to be found, it is said, even in the

[1] "It is certain that the level of the sea cannot fall, the equilibrium of the ocean renders this impossible."—See Leopold von Buch's Gesammelte Schriften, Bd. ii., 1870, p. 504.

Southern hemisphere. New Zealand, for instance, is believed to be rising, while in this case subsidence might be expected, which is in fact pre-eminently the case over the Southern part of the globe. Added to this, the many observations relating to the rise of Scandinavia must—supposing those observations to be right—absolutely prove that rise to depend on an upheaval of the mountains.

The very frequent and distinct sea-levels or ancient sea-margins, which run parallel to the present coast of the North of Norway, should—it seems—be so many more proofs hereof.

Bravais was the first who studied those lines about the Altenfjord. According to his observations, which were afterwards—partly at least—confirmed by Mr. R. Chambers in his "Ancient Sea Margins," two sea-levels are said to extend along the recent coast-line at different elevations above the sea. These lines may be traced, it is said, although interrupted by shorter or longer interstices, from the bottom of Altenfjord towards Hammerfest for a length of about 60 English miles. According to Bravais these two lines are not parallel, either to the present line of coast, or to each other. He found the furrows bending slowly down after their course from the fjord to the outward coast, while at the same time they converge in their relation to each other.

However, the inquiries that have been made into this matter of late years do not tend to confirm the correctness of those observations. The recent researches have not been, it is true, so extensive as necessary to be able to come to any absolute conclusion. Still, there has been noted so much already tending to prove that the opinions of Mr. Bravais are founded on erroneous suppositions, *and that his conclusions must be kept, at least for the present, apart from the range of positive facts.*

But with it falls one of the weightiest arguments for the doctrine of an unchangeable state of the level of the ocean, which has been until now acknowledged, and which theory relies mostly, as we have said, on circumstances along the North of Norway, pointed out by Bravais.

We shall try to give, in the following lines, an account of the result of the researches of late years in this matter.

Mr. H. Mohn, in a treatise published 1877,[1] has collected rich materials towards the explanation of the appearance of ancient sea-levels along the coast of Norway, from Bergen northwards to the Varangerfjord. According to his measurements there is a remarkable recurrence in the levels of those lines within large tracts of the North of Norway (in West Finmark and in the district of Tromsoe). But even about Bergen two of the lower lines correspond in their respective elevations with two similar lines about Tromsoe. It seems quite evident, therefore, that the rise of the whole coast from the very North of Norway to Bergen must have been quite uniform, at least throughout long periods of the Quaternary age.

[1] Bidrag til Kundskab om Gamle Strandlinier i Norge. Nyt Mag. for Naturv, 1877. (Contribution to the Knowledge of Ancient Sea Margins in Norway. New Mag. of Science, 1877.)

In a discussion in 1878, "*On the Sea Levels Engraved in Rocks,*" the author has treated of some of these lines in the neighbourhood of Tromsoe. He proves that upon their course from the outward coast into the fjords—which has been pursued step by step for many miles—they maintain at all points an unaltered height above the sea. If these lines had been bending upwards like those in Alten, as said by Bravais, and at the same measure as those, such a rise could hardly have remained unnoticed.

As the elevation of the shore-lines about Alten, according to what has been stated, have been found to coincide with those about Tromsoe, there will be, even beforehand, no weighty argument in favour of the supposition, that any difference should exist between the Tromsoe and Alten lines, as held by Mr. Bravais. On the other hand, there is some reason to believe that this writer has joined fragments of different sea-levels and terraces together as parts of one line.

Thus the treatise of Mr. Bravais cannot be considered as part of a scientific deduction, or as a proof of an unchangeable state of the sea, while, on the other hand, the rise of the ground all over the Scandinavian peninsula seems to find its best explanation *by supposing a changeable state of the level of the ocean.*

We have remarked already, that the rise of the land over wide adherent tracts of Scandinavia throughout the Quaternary age has, at least through long periods of it, taken place at a slow and exceedingly uniform pace. There is no proof whatever that this rise has been at any part of that age effected suddenly, or by shocks. The rise of Scandinavia, therefore, cannot be simply regarded as synonymous with that of the west coast of South America.

The forces that may have caused the successive secular changes in the sea-level of Scandinavia are purely hypothetical. In fact, as yet no attempt has been made to account for their real nature. It is quite natural that local sinkings or risings should take place, as these may be accounted for by well-known forces. But the rise of all Scandinavia is quite another case. As before mentioned, these changes must have gone on quite uniformly in the tracts from Varanger to Bergen. This is a matter concerning a coast of nearly 2,000 English miles; and, moreover, the whole Scandinavian peninsula is believed to be rising, and there seem to be beforehand weighty reasons to believe that the scale of this rise has been very uniform all over the peninsula, with the only modification, that the coefficient of elevation has declined a trifle, though regularly from north to south.

The East of Finmark and Varanger (that is, the North-east part of Norway) are connected, as to their system of mountains, rather nearer to the tracts of land about the Gulf of Bothnia, than to the West of Norway; consequently, it may be supposed that the changes in the level of the sea about Varanger correspond with those about the Baltic. The observations hitherto made into this respect seem to support such a conjecture. But even if we look only at the coast regions from Varanger to Bergen, these by themselves already form such extensive groups of land, that it will be difficult to imagine the nature of the force that should be able, not only to raise the land, but even to make it so slow and uniform as we have seen—not unlike the rise of the piston in a steam-cylinder. Those powers that have raised such mountains as the Alps, the Himalayas, or the Andes, have worked, it is evident, with a violence quite different. Deep and extensive old strata have thereby been broken, upset, or folded up. The rise of the Norwegian coast through the Quaternary period exhibits little or nothing of this kind. Layers of shells with alternately intersected strips of coarser or finer material lie there, quite unaltered, in their original position, although they had been lifted up from 10 to 12 mètres above the present waters. Shore-lines, at different heights—rising to hundreds of feet above the sea—extend through thousands of miles in an entirely horizontal course. All this seems to indicate that the forces which are pushing Scandinavia upwards are of an entirely different nature from those that have in their time lifted, for instance, the Alps.

Were there any possibility of accepting the theory of a change in the level of the sea, the many different circumstances that appear relative to the rise of Scandinavia would find a plain and natural explanation. By any other supposition, that may be held by science at present, the matter will remain unaccountable and obscure.

The question as to the probability of a change in the axis of our planet during the geological periods, which has been much discussed of late years, seems to have met with a decided negation, as well by natural philosophers as by geologists. If, notwithstanding, the centre of gravity of the earth should have been subject to a change, that displacement must have taken place along its axis, in such a manner, that the latter always retained an unchangeable position.

Whether the cause hereof ought to be explained by the theory of Adhemar and Croll, or is due to other circumstances, it will be necessary, before such a theory can be held, to remove the contradictions that seem to exist in the above-mentioned unequal changes in the sea-level within the same hemisphere.

In this respect it must be remembered at first, that the material hitherto collected concerning the question of changes in the level of the sea through the Quaternary period and the modern age is by far too insufficient to draw, from a broad point of view, any certain scientific deductions. As to the Scandinavian peninsula, it has been held a fact long ago, as is well known, that the north part of it was rising while the south has sunk. But, if I recollect right, it seems to result, according to the researches of late years, that the southern part of Sweden, instead of sinking, is on the contrary about to rise, although, perhaps, not in the same degree as the northern part. Thus there might be at least some possibility that the supposition of a sinking of the West coast of Greenland should prove, by some more careful researches, just as untenable. But even supposing this not to be the case, the question would not be settled yet. Even admitting a changeable level of sea, not every irregularity can be referred to it. On the contrary, it is, as said above, a scientific fact, that sinkings and upheavals of the land throughout all the great geological periods have been effected in a way that seems to prove, without a doubt, that they must have been the results of subterranean forces. Consequently, a sinking of the land may, it is evident, go on within a hemisphere, where at the same time the level of the sea is becoming lower. In order, therefore, to clear up the question in every particular, it will be necessary to examine whether the changes in the elevation of the mountain region are real or only apparent. Only after sufficiently exhaustive researches have been gathered and carefully studied, will it be possible to draw any conclusions, entitled to the name of scientific facts, touching the above question.

IV.—Note on some Fossil Remains of *Emys lutaria* from the Norfolk Coast.

By E. T. Newton, F.G.S.,
of the Geological Survey.

THE remains of a Tortoise from that peculiar fluviatile deposit on the Norfolk coast, known as the "Mundesley River Bed," have lately been placed in my hands for determination by Mr. C. W. Ewing, of Eaton, near Norwich, and, although the European freshwater tortoise has already been recorded as occurring in a fossil condition in Norfolk (Prof. A. Newton, Ann. and Mag. Nat. Hist., 1862, ser. 3, vol. x. p. 224), yet it seemed desirable that some notice should be taken of this most interesting discovery. The specimen was obtained by Mr. Ewing from the peaty bed in the cliff section at Mundesley, so long ago as 1863; but it was only quite recently that it was for the first time exhibited, at one of the meetings of the Norwich Science Gossip Club.

This specimen includes the greater part of the left half of the carapace and plastron, and one costal plate of the right side. None of the neural plates were found, and the first costal of the left side is likewise wanting. Portions of each of the left costals from the second to the seventh are sufficiently well preserved to allow of their being fitted together with the nine marginal plates which are also preserved, so that the general contour of the carapace may be very fairly made out. The nine marginal plates form a consecutive series, the hinder eight of which correspond to the eight costal plates, and each has a pit at its upper and inner margin for the reception of the end of a rib. The marginal plates corresponding to the second, third, fourth, and fifth costal plates, are produced downwards and form an elongated, roughened surface for the attachment of the plastron; but from the nature of this surface it is evident that there was no osseous connexion between the carapace and plastron, but that cartilage or ligament intervened, as in the recent *Emys*. The portions of the plastron which have been preserved are the left xiphiplastron, and pieces of the left hyoplastron and hypoplastron. The last-mentioned bone retaining the ascending process which attaches it to the carapace, while the similar process of the hyoplastron is broken away.

Prof. A. Newton, in the paper cited above, made known to us for the first time, the fact of the occurrence of the European freshwater tortoise, in a fossil condition, in this country. It appears that the specimens were obtained in the year 1836, from below a considerable accumulation of peat (seven feet), at East Wretham, but the true nature of these remains was not recognized until they were seen by the author of that most interesting paper.

The Mundesley specimen does not quite agree with the figures given by Prof. Newton, for when due allowance has been made for their difference of size, it will still be seen, by the grooving of the surface, that the large plates of tortoiseshell overlapped the marginal ossicles to a greater extent in the latter than in the former. By the kindness of Dr. Günther, I had the opportunity of examining the recent specimens of *Emys lutaria* in the British Museum osteological collection, and there I found, as Dr. Günther had already assured me was the case, a very noticeable variation in the extent of this overlap. There is yet another point which deserves a passing notice. In all the specimens of *E. lutaria*, both in the British Museum and in the Royal College of Surgeons, there is a thickening of the outer edge of some of the more anterior of the marginal plates, producing a kind of rounded ridge; the prominence of this ridge varies, being much more obvious in some specimens than in others. This character is not seen in the Mundesley specimen. However, the close agreement between the recent *Emys lutaria* and the fossil from the "Mundesley River Bed," not only in their general form and in the arrangement of their plates, but also as regards the ligamentous connexion of the carapace and plastron, leaves little room for questioning their specific identity.[1]

Prof. Newton tells us in his paper (*loc. cit.*)[2] that the fossil remains of *Emys lutaria* have been found in Denmark and Sweden under conditions similar to those in which the Norfolk specimens occurred, and with regard to the present distribution of the species, we are further told that it is not now known in either Holland, Belgium, N. France, or N.W. Germany. Such being the case, it is not a little interesting to be able to add Belgium to the list of countries from which the *Emys lutaria* has been obtained in a fossil condition. My friend Mr. W. Davies directed my attention to a specimen which is preserved in the Geological Department of the British Museum; it is an almost perfect carapace of this species of tortoise, and formed a part of the rich collection of the late Prof. van Breda, of Haarlem, who obtained it from a freshwater peat-deposit at Ghent, Belgium. This specimen agrees very closely with that figured by Prof. Newton. Here then we have another link in the chain of evidence of the former distribution of *Emys lutaria*.

[1] The Mundesley specimen has recently been secured for the Norfolk and Norwich Museum, where it is now preserved.

[2] See also his paper on the Zoology of Ancient Europe, read before the Cambridge Phil. Soc., March, 1862.

It may be interesting to note that Lyell (Antiquity of Man, 4th edit., p. 268) records the following remains from the black peaty deposit of Mundesley:—"Shells of *Anodon, Valvata, Cyclas, Succinea, Limnea, Paludina*, etc., seeds of *Ceratophyllum demersum, Nuphar lutea*, scales and bones of pike, perch, salmon, etc., elytra of *Donacia, Copris, Harpalus*, and other beetles." He also includes *Paludina* (*Hydrobia*) *marginata*, but this has very recently been identified by Mr. H. Norton with the *Bythinella gibba* figured by Moquin-Tandon.[1] I may also add that a detailed account of the Mundesley bed, with some additions to its list of organic remains, will be given in the Geol. Survey Memoir on the Cromer District, by Mr. Clement Reid.

The following notice of opinions on the subject of the age of the bed has been kindly furnished to me by my friend and colleague Mr. H. B. Woodward:—

Age of the Mundesley River-bed.

[The Mundesley River-bed occupies a hollow eroded in the Lower Glacial Beds (Cromer Till or Lower Boulder-clay, and Contorted Drift). At one time it was held both by Lyell and Joshua Trimmer to be intercalated in this Drift;[2] but Mr. Gunn and Prof. Prestwich subsequently showed that the Freshwater deposit really overlaid the Lower Boulder-clay, a view in which Lyell himself coincided.[3] By them it has since been spoken of as a Post-Glacial deposit. It is, moreover, interesting to note that Mr. Prestwich pointed out some resemblances between the Mundesley bed and that at Hoxne, which is so well known as the locality for many palæolithic implements; and he went so far as to suggest a search in the Mundesley bed for these flint weapons. The Post-Glacial age of the Hoxne bed has, however, been recently called in question by more than one authority;[4] while the stratigraphical evidence at Mundesley merely shows that the river-bed is newer than the Lower Glacial Beds. There is nothing to prove it might not be older than the Chalky Boulder-clay; or, in other words, to determine whether it be Inter-Glacial or Post-Glacial. The occurrence, therefore, of the remains of the *Emys lutaria*, taken in conjunction with the position of the remains of this species elsewhere, tend to prove that the Mundesley River-bed is Post-Glacial.—H. B. W.]

EXPLANATION OF PLATE VIII.[5]

Fig. 1.—*Emys lutaria*, left side of carapace, seen from above.
,, 2. ,, ,, ditto with plastron, side view.
,, 3. ,, ,, portion of left side of plastron, seen from below. Hyo. Hyoplastron; Hypo. Hypoplastron; Xip. Xiphiplastron.

[1] Trans. Norfolk and Norwich Nat. Soc., vol. ii. p. 357.
[2] Lyell, Phil. Mag. 1840, vol. xvi. p. 353; Trimmer, Quart. Journ. Geol. Soc., vol. vii. p. 20.
[3] Prestwich, Geologist, vol. iv. p. 68; Lyell, Antiquity of Man, 4th ed. p. 267.
[4] J. Geikie, Great Ice Age, 2nd edition, p. 525; Belt, Quart. Journ. Science, July, 1876.
[5] The appearance of this Plate is unavoidably delayed till the August Number.—Edit. Geol. Mag.

V.—Pleistocene Geology of Cornwall.[1]

By W. A. E. Ussher, F.G.S.

Part V.—Blown Sands and Recent Marine.

Notes on Blown Sands and Gravel Bars.

Proceeding round the coast from Plymouth.

1. Par. A low range of sand dunes separates the alluvial tracts from the Par sands.

2. Pentuan. A bank of coarse granitic sand, with bedding and false bedding indicated by black bands of schorlaceous material, dams off the sea from the low land at the mouth of Pentuan stream; on the landward margin of the low tract a low range of sand dunes has accumulated, apparently from the wind drift off the sand bank; the surface of the alluvium between them is strewn with similar granitic sand.

3 *a.* Falmouth. At the curve in the shore at Gyllyngvaes (Claypole, Proc. Brist. Nat. Soc. Ser. 2, vol. v. p. 35) the top of the gravel beach or bar coincides with the highest spring-tides.

b. Swan Pool is dammed by a bar of small quartz pebbles, 80 yards broad, and in the highest part 5 feet above high-water.

c. Mr. Godwin-Austen noticed (Rep. Brit. Assoc. for 1850, Trans. of Sects. p. 71) a platform of bare rock near Falmouth, occupying an intermediate position between high-water mark and the base of the adjacent raised beach, which varies from 3 to 10 feet above it.

d. Between Pennance Point and Maenporth, rock platforms occur at about the level of spring-tide high-water, the traces of raised beach in the vicinity being about 4 feet higher.

e. South of Maenporth, rock reefs and platforms were noticed at about 6 feet above ordinary high-water, the base of the adjacent raised beach being 10 to 15 feet above that level.

4. A strip of blown sand flanks the stream at Poljew; at Gunwalloe a considerable accumulation of blown sand covers high land between Castle Mount and Towan. On N.W. of Castle Mount, owing to the exposed situation, no blown sand occurs.

5. The Loo Pool is dammed by a bar of small quartz pebble gravel and coarse sand, with occasional flint and slate materials: coarse brown blown sand caps the low cliffs to the south of it.

6 *a.* Penzance.

Dr. Boase (T.R.G.S. Corn. vol. iii. p. 131) gives a section of the West Green sand bank, between Penzance and Newlyn, as follows:—

1. Granitic sand, of quartz, mica, hornblende slates with a little tin ore; quartz predominating ... ... 10 feet.
2. Gravel, of hornblende slate pebbles from 1 to 3 inches in diameter, 16 feet thick, resting on a submerged forest.

He points out the difference between the present sea sand and that forming the Green sand banks, between Marazion and Penzance and Newlyn; the former being finer, and composed of pulverized clay-slate and elvan, whilst the latter appears to have been derived

[1] Concluded from the June Number, p. 263.

from the destruction of a continuous band of granite between Mousehole and Cudden Point.

The original length of the Green (*op. cit.* vol. ii. p. 136) "was about three miles on the east and one mile on the west of Penzance; and is already much shortened. The ancient breadth is unknown." The West Green contained but two or three acres, and in no place exceeded 130 feet in width, when Dr. Boase wrote (*op. cit.* vol. iii. p. 131, etc.); whilst in Charles the Second's time it is mentioned in a letter to Mrs. Ley, of Penzance, as affording 36 acres of pasturage.

b. Mr. Edmonds (Edin. New. Phil. Journ. vol. xlv. p. 113, for 1848) mentions the following facts. Seventy years ago a meadow lay outside the present sea-wall at the entrance to Newlyn; several houses and gardens stood on the seaward side of the cottages at Sandy Bank in Penzance; these extremities of the old Western Green are no longer visible.

In 1843 a sea-wall was built by the Corporation of Penzance to protect the remainder of the sand bank. Off the eastern bank numerous rocks between high- and low-water mark, below both sand banks, near Newlyn, Chyandower, and Marazion, buried beneath 4 to 5 feet of sand 40 years previous to 1848, were uncovered.

c. In the sand bank between Penzance and Marazion, near Marazion Bridge, Mr. Edmonds discovered a great number of land shells (*Helix virgata* and *Bulimus acutus*), in perfect preservation, throughout a depth of about 10 feet from the surface. In one instance, in the same locality, he observed a layer of small rounded pebbles, an inch or two in thickness, 3 feet below the surface of the sand, and more than 15 feet above the level of high-water. In the subjacent sand, for 4 or 5 feet in depth, he found numerous perfect land shells.

7 *a.* Whitesand Bay, to the North of Sennen Cove, is bounded by sand dunes, capping the low cliffs, and extending for a little distance inland, surrounded by higher ground.

b. On the north side of Cape Cornwall rock platforms are visible at about high-water mark, the traces of raised beach adjacent are about 6 feet above that level.

8. Lelant, Phillack, and Gwythian Towans.

"The Cornish word 'Towyn,' says Mr. Edwards (T.R.G.S. Corn. vol. vi. pp. 300–304), means 'a turfy down,' the word 'down' being perhaps a mere corruption of 'towyn' by the very common change of the letter *t* into *d*; and it is remarkable that the name 'Les Landes,' 'barren heaths,' given to the sandy districts on the S.W. coast of France, is almost precisely the same with 'Lelant,' the parish in the Towans where an ancient market town is said to have been buried by the sand. Hence Towans, Downs, Lelant, and Les Landes may all be regarded as synonymous."

In the same paper he characterizes the blown sands of St. Ives Bay as accumulations of comminuted shell sand nourishing a scanty growth of *Arundo arenaria.*

a. North of Hayle and west of Phillack an excavation of about 30 feet, at the termination of a tramway, afforded me a good section of the blown sands, here consisting of rather fine buff sand, made up of a mixture of quartz grains with comminuted shells, intersected by numerous dark bands near the top, apparently dipping northward at 10°, as though caused by the successive entombment of rank grass surfaces under gradually accumulating sand. Below the dark bands the sand still presents an appearance of bedding, such as might be occasioned by successive slips from an eminence, wherever the slopes became too sharp for the accumulating sand to rest. From this bedded appearance, and from the frequent linear distribution of perfectly preserved land shells, (*b.*) Mr. Edmonds (*op. cit.*) considered that the sand in its gradual accumulation had buried the latter "without ever completely covering the growing turf whereon the animals were feeding or hybernating."

c. Mr. Boase (T.R.G.S. Corn. vol. ii. p. 142) says, "In some places where the sand has been bored to a great depth, distinct strata separated by a vegetable crust are visible; which seem to indicate a succession of inundations at distant periods; but it is possible . . . . that this may be owing to a local shifting of the sands, because in other places the like series of strata is not found."

d. In a deep cutting in the sand, about a mile from the sea, Mr. Edmonds discovered a nest of small land shells, 50 feet from the surface, of the following species:—*Helix virgata, Zonites radiatulus, Bulimus acutus, H. pulchella, Zua lubrica, Vertigo edentula, Pupa marginata, P. umbilicata, P. anglica, Bithinia ventricosa.*

He gives the following list (T.R.G.S. Corn. vol. vii. p. 71) of shells found under the surface of Phillack Towans (those marked with an asterisk are now living within 10 miles of Penzance).

Bulimus acutus.	*Helix fulva.**	*Vertigo edentula.*
—— *obscurus.*	—— *fusca.*	—— *palustris.**
Carychium minimum.	—— *hortensis.*	—— *pygmæa.**
Clausilia biplicata.	—— *nemoralis.*	*Vitrina pellucida.*
Conovulus bidentatus.	—— *pulchella.*	*Zonites alliarius.*
—— *denticulatus.*	—— *virgata.*	—— *cellarius.*
Helix aspersa.	*Pupa anglica.*	—— *nitidulus.*
—— *caperata.*	—— *marginata.**	—— *pygmæus.*
—— *ericetorum.*	—— *umbilicata.*	—— *rotundatus.*

Mr. Edmonds mentions the occurrences of numerous shells of *Helix pulchella*, at depths varying from 1 to 30 feet, in various parts of the sands, and says that living specimens have been observed, and that their exuviæ have been found in Whitesand Bay sandhills as well as those near Gunwalloe and Mullion, Mounts Bay, and Gorran (on the South Coast of East Cornwall).

Mr. Crouch, who identified the species given above, observes that *Helix pulchella* is uncommon in the locality, that it has been found by him near Falmouth, at Pendennis; and near Penzance, at Trereife; also near the Land's End.

From the quantity of shells found in so small a space in the Towans, Mr. Crouch considers that they were once abundant in Cornwall, but are now gradually becoming extinct.

Pupa marginata and *Bithinia ventricosa* he alludes to as rare, a few dead shells having been obtained by him at Whitesand Bay (Land's

End) and near Hayle, but that no live specimens have been found in Cornwall.

e. Near Godrevy Island, rock platforms are visible at about the level of spring-tide high-water; the base of the adjacent raised beach is from 4 to 5 feet above ordinary high-water.

9. Mr. N. Whitley (25th Ann. Rep. Roy. Inst. Corn. for 1843) mentions "the succession of sand hills, principally composed of comminuted shells, covering about 1,500 acres, on the north-east of Perran Porth. The inland portion," he says, "being level and well sheltered, might easily and profitably be reclaimed by an admixture of clay with the sandy wastes, as in Norfolk, where by this means a free sandy loam, forming a most productive soil, has been obtained. Owing to the extent of the Perran Sands, being more heated by the sun's rays than the surrounding districts, in calm weather by the radiation of heat from the sand hills, it is often oppressively warm at the Porth during the early part of the night."

10. The patch of blown sands bordering Hollywell Bay may be regarded as a continuation of the Perran Sands, it is partly bounded by a stream.

11. The flattish tract between New Quay and Fistral Bay is covered by blown sand.

12. Sand dunes occur at Porth Barn, Mawgan Porth, and Porthcothan, Tregarnon, and Permizen bays; they are very insignificant.

13. Between Constantine and Perleze Bays a low tract is covered by blown sand; as exposed near Constantine Island (*vide* Raised Beaches, 19 *e*), it is 4½ feet in thickness, and contains layers of *Patellæ* and broken *Mytili*, and occasional angular slate fragments at the base.

14. The low tract in which St. Enodock's Church is situated is composed of blown sand.

15. In Perleze Bay, and near Port Isaac, rock platforms were noticed at about ordinary high-water mark.

General Notes.

Wherever the area covered by the blown sands is extensive, we note that the lands generally lie low with reference to the sea or relatively to the surrounding country: That the accumulation spreads from west to east, and only occurs in considerable quantity in localities at or near the coast-line facing westwards.

Thus, in bays where the cliffs are very low and unbroken by gorges or stream channels, facing westwards and receiving the full force of winds and waves of the Atlantic, the most favourable conditions occur for æolian transport on the Cornish coast.

Naturally, the inland extension of the sand depends upon the extent of low-lying country; but, besides this check on its extension exercised by barrier hills, running water and the growth of certain plants may arrest its progress; the former intercepts the fugitive grains which seldom rise more than a few inches above the ground and are suspended for a short time (De la Beche, Report, etc., p. 446). As to the latter, Major T. Austin (Proc. Brist. Nat. Soc., vol. ii. No. 11, for Dec. 1867) gives the following plants as best suited to arrest the inroads of blowing sand, in some cases by collecting hillocks kept together by their matted roots—*Ammophila arenaria* (sea reed); *Triticum junceum* (sea wheat grass); *Hippophœ rhamnoides* (sand thorn); *Cakile maritima* (sea rocket); *Salsola kali* (salt wort); and *Sonchus* (sand thistle).

Mr. Henwood (40th Ann. Rep. Roy. Inst. Corn. for 1858) alludes to the progress of the sand drift covering the low lands of St. Minver, on the east of Padstow, being checked by the growth of *Arundo arenaria.*

The appearances of bedding in the blown sands are worthy of note, as they betray the incipient characters which in the old blown sands of Fistral Bay and Greenway have developed on consolidation into marked laminæ or thin flaggy sandstones, and near Godrevy and New Quay into thick beds. Although the constant shifting and accumulation of the sands (8 *b*) upon a growing surface must be true, yet the final entombment and successive growth of grass, or *Arundo arenaria,* is more likely to have been occasioned by heavy gales drifting large quantities of sand upon the dunes (8 *c*); for, constant shifting of particles would be less likely to produce definite layers; the cohesion of the particles of successive surfaces of comminuted shell sand lending itself readily to the formation of definite beds, and when counter wind drifts prevailed, to false beds, in the process of consolidation through the downward passage of rain waters. But as far as I am aware no traces of old vegetable surfaces have been found in the old consolidated blown sands. The false-bedded appearance is well shown in the old blown sands of Barnstaple Bay. The thin layers of schorlaceous and quartzose grains in the sand bank at the mouth of the Pentuan Valley seem to be due to marine action, sorting the materials.

The absence of sand or gravel bars on parts of the Cornish coast directly exposed to the waves of the Atlantic, and their limitation on the southern coast to sites where promontories and headlands shelter them from the direct influence of the prevalent winds, and where the rapid transport of shingle is lessened by projections of the coast on the further side, is worthy of note. Thus, the West Green bank sheltered by the Land's End district occurs in the centre of Mounts Bay; the Loo Bar, somewhat similarly sheltered, has been piled up where the southerly trend of the Lizard coast-line becomes pronounced; the Swan Pool Bar and the extensive beaches of Falmouth, lying between the flow of the Fal and Helford nearly at right angles, are sheltered in a measure by the Lizard district, and the further transport of shingle is checked by the projection of Pendennis Point.

The set of the coast-line has been aided by the inability of the stream waters to keep a seaward passage clear, as in the case of the Loo Pool, which represents the ponded drainage of the Cober and its tributaries. The ceremony of cutting the Bar annually to allow the waters to escape more rapidly than by filtration through it, and thus prevent floods, shows how effectually the seaward outlet of the stream has been overcome. The finer accretions to some of the banks, as in the West Green, have been shifted higher by winds; a tongue of sand occurs on the east of the Loo Pool similarly drifted.

The surfaces of the planed Killas reefs, of which I have only given a few examples, occupy in most cases a position intermediate between the base of the several raised beaches in their vicinity and high-water mark (3 *c*, *d*, *e*; 7 *b*; 8 *e*; 15). Mr. Godwin-Austen attributed (Rep. Brit. Assoc. for 1850, Trans. of Sects. p. 71) their positions to a recent elevation (preceded by a subsidence) of not more than 10 feet. In further proof of this he cites the mud beds of the Exe and Sussex Ouse, containing estuarine shells at slight elevations above the present sea-level. The occurrence of many of the rock platforms are explainable without invoking changes of level. The comparatively recent subsidence by which the forest lands were submerged would have brought again within the influence of the waves such portions of the old platforms, upon which the raised beach rested, as had survived the intervening subaerial waste, and, whilst robbing them of whatever superimposed deposits might have existed, would plane anew those more durable portions which came within the influence of the waves, leaving others shorn of their deposits, marking by the heights of their surfaces the seaward slope of the old plane of marine denudation. Bearing in mind the very unequal heights of old beaches of the same age, and the irregular levels of their platforms in places at the base of the same cliff (in places, as in Fistral Bay, the base of the raised beach occupies an almost uniformly persistent level), except where great discrepancies in their levels with reference to adjacent raised beaches occurred, the platforms might be explained as above. Other phenomena, however, whilst in no way interfering with the above explanation, would appear to favour the idea that a pause in the downward movement, after the submergence of the forests, was succeeded by a slight contrary movement. Such an oscillation might serve to explain the river sediments gaining on the marine, in estuarine stream tin sections, and to enable them to continue *pari passu* with a resumption of the subsiding movement. If, from the sections in Marazion Marsh given by Messrs. Henwood (T. R. G. S. Corn. vol. v. p. 34) and Carne (*Ibid.* vol. vi. p. 230, etc.), we may place the top of the marine bed at 2 or 3 feet above high-water, an oscillation would alone account for its position. The formation of the Warren Sand Bank and Northam Pebble Ridge might also be explained by a slight elevation, whilst the rapid diminution of both would seem to indicate a return to the previous contrary movement. The formation and diminution of the West Green Sand Bank might be similarly explained.

Mr. Edmonds (Edin. New Phil. Journ. for 1848), commenting on the diminution of the bank, says, that 300 years ago, in Leland's time, the causeway leading to St. Michael's Mount was uncovered six hours out of twelve, and continued so for 220 years. The passage to the Mount in 1848 was open four hours out of twelve, and often during strong S.W. winds covered at neap tides for days together. He ascribed these rapid changes (6 *b*) within 80 years to the removal of sand, which supported the western side of the ridge, for ballast and agricultural purposes. "Some idea," he says (T. R. G. S. Corn. vol. vii. p. 31), "of the vast quantity of sand thus abstracted (for manure) may be formed by the fact that a very usual clause in farming leases in this neighbourhood is, 'That ten butt loads of sea sand shall be spread on every acre whenever it is broken for tillage.'" This explanation is a very plausible one, and, coupled with the hypothesis before mentioned, would be a powerful adjunct in accounting for more rapid recent waste. Great quantities of comminuted shell sand are also carted from Bude by the farmers of North-west Devon.

In conclusion, I have to express my sincere thanks to Mr. W. Whitaker, Dr. C. Le Neve Foster, and to Mr. E. Parfitt, of Exeter, for kindly furnishing me with all the information in their power concerning the literature of the subject; to Mr. Robert Hunt, F.R.S., Keeper of the Mining Records, for placing at my disposal some beautifully executed sections of the St. Agnes deposits by Mr. A. C. Davies, some of which I have submitted to the Geological Society in a reduced form; also to Mr. Horace B. Woodward for the kind interest he took in this paper in its original form, and the information he obtained for me as to the best means of insuring its publication.

VI.—On the Source of the Erratic Boulders in the Valley of River Calder, Yorkshire.

By James W. Davis, F.S.A., F.G.S., etc.

The reference, in my paper on the Calder Valley, to the extensive deposits of boulders and sand which fill up the lower part of the valley, and form a series of long level surfaces, is necessarily very brief. It may assist a proper understanding of the subject, and the point raised in Mr. Dakyns' letter, if I recapitulate, as briefly as possible, the main facts of the case. The river has its source in two or three small streams which rise in the hills on the Lancashire side of the Pennine Anticlinal. These are joined into one stream, and pass along a narrow but deep valley cut at right angles to the range of elevated gritstone hills which form the boundary between Lancashire and Yorkshire. For five or six miles the valley is rarely more than about 200 yards in breadth, and on each side the slopes of the hills are extremely steep, composed of shales, surmounted by a precipitous gritstone escarpment. At Hebden Bridge the Calder is joined by the Hebden, and in its course south-eastwards the valley gradually assumes larger dimensions, and south of Halifax spreads out into extensive level plains, along which the Calder has carved its channel with many devious turnings. On reaching the district from Mirfield to Wakefield these characteristics are still more apparent, its path being amongst the softer beds of the Coal-measures. Below Wakefield to the confluence of the Calder with the Aire at Castleford, the country generally is of a comparatively flat and uninteresting nature.

The lower reaches of the valley are filled with great quantities of gravels, sand, and boulders. At Wakefield wells have been dug to a depth of twenty-eight and thirty feet, and at Thornhill and Dewsbury excavations have proved the deposits to be between forty and fifty feet in depth. Still further up the valley, from Elland to Sowerby Bridge, the gravels and boulders occur in some force, and are at least twelve to sixteen feet deep. The valley nearer its source than the latter locality is almost devoid of gravels; and where they do occur, as at Mytholmroyd, the travelled boulders are rare, or altogether absent. From Sowerby Bridge southwards the drift or gravel is composed of rounded pebbles and sand; these, near the surface, are almost entirely derived from the local sandstones and Calliards; in the lower strata boulders of granite, trap, and syenite become gradually more frequent, until in the lowest parts they attain a great preponderance, and rocks of local origin are almost as rarely found as crystalline ones were in the upper part of the series. In the sections low down the valley, the boulders are frequently of considerable size, and at Dewsbury masses of granite and limestone were found near the base of the section exceeding a foot in diameter; they were in all cases well rounded and quite devoid of scratches. The following section of a well sunk at Dewsbury may be taken as an average example:—

1. Earth and sandy subsoil...	7ft.	6in.
2. Boulders, consisting in the upper part of sandstone with a slight intermixture of granite, etc., gradually merging into	24ft.	0in.
3. Boulders, almost entirely of crystalline rocks not occurring in the district *in situ*	6ft.	0in.
4. Clay with sand and boulders...	5ft.	0in.
Carboniferous sandstone		

A remarkable circumstance is the occurrence in the lower beds of rounded masses of flint, along with granite, syenite, and trap rocks, the latter having been identified with their parent rocks in Westmoreland and Cumberland, and even in some few instances with rocks of Scotch derivation, whilst the flints are similar to those occurring in the Chalk in the eastern parts of the Yorkshire Wolds. There is an entire absence of shells of Mollusca, but near Thornhill the trunks of several trees have been found at a few feet below the surface of the gravel beds, presenting an appearance indicating that they grew at no great distance from the position they occupied when found. A more detailed description may be found in the Proceedings of the Yorkshire Geological and Polytechnic Society for the year 1875, page 93.[1]

In addition to the boulders already enumerated, Shap Fell granite has been found in the district south-east of Wakefield. Though comparatively rare, they are found sufficiently often to form a characteristic boulder; the large masses of pink felspar being a very important constituent, which renders their identification unmistakable. The occurrence of this granite, as will be shown hereafter, throws a most important light on the origin of the gravels.

[1] See also a paper by J. Travis Clay, Esq., of Rastrick, Proc. Geol. and Polyt. Soc. of the West Riding of Yorkshire, vol. i. p. 201 (1841).

The question at issue is, "How were the erratic boulders transported into the Valley of the Calder?" There are two sources from which the boulders may have been derived, the one on the western side of the Pennine range of hills dividing Lancashire and Yorkshire, and the other occupying a part of the great plain of the Ouse in the central part of Yorkshire. In all probability the glacial clays, originally containing the boulders, may have had a common origin in the mountainous ranges of Westmoreland, or possibly amongst the mountains of the south of Scotland. Whether one or both these localities served as the source of the glacier, it appears to have passed along the valley of the Eden, grinding against the Crossfell escarpment until it reached the somewhat lower ground of Stainmoor Forest. At this point a part of the glacier was deflected eastwards over hills rising to a height of 1,500 to 1,600 feet above the sea-level into the valleys of the Tees and its tributaries, and also into Arkendale and Swaledale, which are branches from the valley of the Ouse. The glaciers penetrated far down the valleys, and the immense quantities of boulders and till left on their recession testify to their great size and importance. The second portion of the Eden Valley glacier, which did not pass over Stainmoor, continued its course in a southerly direction, and one part of it, filling the valley between Mallerstang and Wild Boar Fell, passed along the district known as Lunds and entered Wensleydale. Mr. J. G. Goodchild [1] has demonstrated that this glacier must have been 1,600 feet in thickness, and points to numerous evidences of its extent and action in this, and the tributary dales of Snaizeholme Widdale and other streams. The remaining portion passed along the western escarpment of the Pennine Chain, and deposited great thicknesses of Boulder-clays in the valleys of Lancashire. Mr. Dakyns is of opinion that the latter is the source whence the "erratics may very well have been washed down out of these glacial beds into the Calder Valley by ordinary rain and river action," and I believe that this opinion is also shared to a great extent by other officers of the Geological Survey.[2] It has already been observed that the sources of the Calder are extended to the Lancashire side of the Pennine Anticlinal, but an inspection of the country drained by it shows that it is surrounded by high hills, with the exception of the two valleys along which the railway lines run north-westwards to Burnley and southwards to Littleborough. The watershed between Burnley and Littleborough is formed by a series of hills rising about 1,400 feet above the sea-level, extending from Shieveley Pike and Heald Moor southwards to Tooter Hill and along Trough Edge to the summit near Walsden. Throughout the whole of this district on the Yorkshire side of the watershed, with the exception of a small patch of gravel in Walsden, near the Waggon and Horses public-house, there is no trace of gravel or drift. The beds of the several

[1] Quart. Journ. Geol. Soc. vol. xxxi. p. 73.

[2] See also "Notes on the Lancashire and Cheshire Drift," by E. W. Binney, read in 1842, and printed in the Transactions of the Manc. Geol. Soc. vol. viii. part i. page 30 (1869).

streams in Dulesgate, Howroyd Clough or Ramsden Clough, though deeply cut, exhibit no sections in which drift can be found. On the western or Lancashire slopes of the hills Boulder-clays and drift occur, often reaching a thickness of 150 to 200 feet. In excavating Hollingworth Reservoir, which is four or five miles west of the summit, and 568 feet above sea-level, extensive beds of gravels were found, which contained marine shells of the genera *Fusus*, *Cardium*, *Purpura*, *Neritella*, etc. Marine shells in the Drift are not uncommon in other parts of the district.

The Yorkshire and the Lancashire Calders rise near together at Calder Head. The latter is fed by many small tributaries which have their source on the slopes of the hills eastwards. These tributaries have formed deep valleys or cloughs, and exposed great thicknesses of gravel and Boulder-clay. Good examples may be seen in Cant Clough and Hurstwood Brook near Worsthorn, and in the Catlow and Thursden Brooks. The boulders have been derived from the Boulder-clay, which still in many instances is found at the base of the Drift. The latter is composed mainly of Carboniferous limestones and sandstones, with an intermixture of Silurian grits, traps, quartzites, and granites. The Carboniferous Limestone occurs in such abundance that it was formerly very extensively used for burning to obtain lime. The remains of lime-kilns may be seen studding the hill-sides throughout the locality. In the valley with Burnley for its centre the remains of glacial origin occur frequently. The gravels in the valley of the Yorkshire Calder *may* have been derived originally from the Boulder-beds in these districts, but a glance at the physical features of the district renders this view of the case somewhat problematical. The distance from Todmorden to Burnley is $9\frac{1}{4}$ miles. The two Calders rise at Calder Head four miles from Todmorden. The valley of the Yorkshire Calder, running south-eastwards, is narrow, rugged, and falls rapidly from a height of more than 700 feet above the sea-level at the summit, to about 380 feet at Todmorden. On either side the valley the ground rises rapidly and is surmounted by precipitous escarpments of sandstone. The Pennine Fault runs in a line with the valley, and has displaced the rocks, so that those on the Lancashire side are composed of the Third Grit, the opposite one being thick beds of the Kinderscout Grit. Surmounting the latter, the picturesque groups of weathered rocks, the Bridestones and Hawkstones, ornament the sky-line. Near the source of the stream the Lower Coal-measures set in, and the sides of the valley being, in consequence, of a much looser and more friable nature, landslips have resulted, producing a great number of rounded hillocks. The Lancashire Calder rises and runs in a similar narrow valley falling with equal or still greater rapidity in the opposite direction, the bed of the stream at Burnley being 350 feet below that of its source. Beds of gravel are occasionally exposed in the sides of the stream, as at Walk Mill, two miles from its source and 200 feet less in elevation, where, beneath a bed of peat, principally composed of the remains of hazel trees, there is a rough sandy gravel; the contained stones are for the most part semi-angular, and have all been derived from the neighbouring hills. Granites, limestones, or other travelled boulders, do not appear to be present. Some distance lower down the valley, as Burnley is approached, however, the travelled boulders become common.

If the erratics in the bed of the Yorkshire Calder were derived from the Boulder-clays east and north-east of Burnley, it is quite evident that they could not have been transported by river action. The great rise to the summit of drainage disposes of that theory. The only agent equal to the task appears to be drifting icebergs. It is possible that large masses of ice may have been in existence in the Burnley Valley, and these, becoming loose and floating away, would carry with them any stones or boulders with which they happened to be in contact. In order that these icebergs should be able to float over into the valley of the Yorkshire Calder, it would be necessary that the land should be lowered to the extent of between 750 and 800 feet, so that the sea might overflow the summit to a sufficient depth to afford a passage for the ice-floes and their contents. There are also other objections to this method of their entrance into the valley; amongst others, that the valley is entirely devoid of erratic blocks or boulders for many miles from its source, and it is only when the lower parts are reached, that they occur, and the nearer the mouth of the valley, the more numerous are the boulders. It might also be expected that some of the boulders would lie strewn on the sides of the hills, bounding the valley; but hitherto both the hill-sides and their tops have proved entirely devoid of such evidence. For eight or ten miles the deep valley does not present any sections exposing erratic boulders. At some distance below Hebden Bridge, Dr. Alexander[1] quotes Mr. Gibson as having found a few fragments of granite or trap whilst the railway line was in process of construction, and a few well-rounded boulders are occasionally found at Mytholmroyd, two miles further down the valley, but they do not occur in any considerable quantity until North Dean is reached.

Turning next to the second source whence the Boulders may have been derived, it is well known that the Valley of the River Ouse contains immense quantities of Boulder-clay, Brick-earths, sands, and gravels, derived from the glaciers which it has been shown descended Swaledale and Wensleydale. The Boulder-clay may be considered as the foundation on which the others are deposited, and where it has not been subjected to the action of water, still extends across the whole breadth of the valley from the elevated Permian Limestone plateau on the west to the Liassic and Oolitic wolds on the east. Sections exposing the relative position of the series in the valley are not frequently exposed. The Boulder-clay occurs extensively east of Knaresborough, and southwards; and on the opposite side of the valley it is 60 or 80 feet thick near Easingwold. At York the Boulder-clay is 70 feet thick, and the new railway station works are all built on this material. South of the River Wharfe the clay has a thickness of 60 feet. It contains immense quantities of scratched stones, boulders of Mountain Limestone are numerous; pink

[1] Proc. Geol. and Polyt. Soc. of the W. Riding of Yorkshire, vol. i. p. 148.

granite, trap, syenite, and others, derived from the mountainous districts, are common, and mixed with these there are also boulders of sandstone, chert, and chalk. The centre of the valley is covered with deposits of a more recent origin; sands and gravel occur plentifully, and appear to have been derived from the glacial clays beneath by the disintegrating action of water. The stones are generally more rounded, and the striæ or ice-scratches have been removed by attrition. In a few cases, the boulders still retain scratches. "These sands frequently exhibit very irregular stratification, and occasionally the beds are much contorted, as if from lateral pressure, such as might be produced by icebergs grounding in shallow water." [1]

There is little trace of glacial deposits on the Permian Limestone, but on the western side, in the valley of the Aire, there is abundant evidence of glacial action. The hollow in which Bradford is situated is covered with a thick deposit of Boulder-clay, and at Guiseley and Apperley Bridge, patches of similar drift occur. North of Leeds great masses of drift are found, consisting principally of stiff blue clay, containing rounded and angular stones of local origin, as sandstones and grit, and also many others of foreign origin, granite and trap being the most common. At Whinmoor, at a height of 380 feet above the sea-level, a boring went through 114 feet of Boulder-clay. These deposits are probably the remains of an old glacier, which descended the Valley of the Aire from the neighbourhood of Skipton. It is within the range of possibility that this glacier may have extended as far south as the neighbourhood of Barnsley, for Prof. A. H. Green has described a bed of glacial clay [2] filling a basin-shaped hollow about two miles north of that town. The exposure is three-quarters of a mile in length; the Boulder-clay is divided into Upper and Lower, and contains, besides stones of local origin, boulders of highly metamorphosed breccia, granite, and others, from the Lake District. There are other patches of glacial clay scattered over the district, and also quantities of drift. From a consideration of all the facts, Prof. Green arrives at the conclusion that the whole district was probably covered by a layer of Till or Boulder-clay, resulting from the presence of an ice-sheet which probably had its termination in this district, and being thin could not exert a very great influence in grinding up the rocks over which it passed. The greater part of the Boulder-clay so deposited has since been removed by denudation.

The glacier, whose existence is thus indicated, descended from the northwards, and consequently must have crossed the lower part of the valley of the Calder in the neighbourhood of the place where Wakefield now stands, and several miles west of its confluence with the Aire at Castleford. The facts already stated, though very briefly, go to prove that on the recession of the glaciers which once enveloped the country north of the hills separating the Calder from the Aire, immense quantities of stiff glacial clay, filled with sub-angular, scratched boulders of both local and distant origin, were left filling up the valleys. The land appears at this period to have been

[1] Memoir of the Geological Survey illustrating Sheet 93 N.W. p. 14.

[2] Proc. York Geol. and Polyt. Soc. 1876, new series, pt. iii. p. 122.

submerged to the extent of some four or five hundred feet, and the glacial clays subject to the denuding and abrading action of water. The boulders released from the clay, and rolled hither and thither by the waves, were gradually reduced to a more rounded form, and by the same process the scratches were obliterated. There can be little doubt that to this action is due much of the sand and gravel existing in the Valley of the Ouse, and also in the Aire Valley in the neighbourhood of Leeds. The climate appears to have been still cold, and icebergs, broken off from the receding ice-sheet, or masses of ground-ice bearing the boulders frozen from the bottom into their mass, drifted in every direction, and, melting, dropped their burden of boulders in new localities.

Under such circumstances as these the Valley of the Calder would be an estuary from the sea, of considerable width at its mouth, and gradually closing inland to a comparatively narrow channel. The united action of the floating icebergs and the tides would be amply sufficient to account for the presence of the boulders which have already been described. They are most abundant in the lower and wider parts of the valley, and the boulders of distant origin preponderate in number, in every section, in the lowest beds, those higher in the series being for the most part, and near the surface entirely, composed of sand and boulders of local origin. The icebergs would in the first place supply the erratics in the lower beds, and as the ice-sheet still receded, and a warmer climate prevailed, the rolling action of the tides reduced the boulders higher in the series from the rocks of Carboniferous age which surrounded the valley and were constantly being broken away by the action of the water wearing away the shales supporting them.

The fact that in all the sections which have been noted in the lower part of the valley, the erratic boulders are always most numerous, and that they are much larger in size, frequently a foot or more in diameter, at the base of the section, diminishing in size and frequency higher up until they are lost completely, and layers with only stones of local derivation occur. In the higher parts of the valley, as at Elland and North Dean, where the beds are half the thickness of those at Wakefield or Dewsbury, no large boulders have been found, and they are rarely seen to exceed two or three inches in diameter. There is also a great decrease in the proportionate number of foreign and local stones even in the lowest beds. This arrangement of the heavier boulders at the base of the sections, and especially their localization in the lower parts of the valley, points most clearly to their eastward origin and the sorting action of the sea. Had they come westward by river action, the largest boulders would have been left in that part of the valley nearest its source, or, if carried to their present positions, would have been disposed indiscriminately with smaller ones throughout the whole section.

That the latter theory is probably the correct one, receives additional support from the occurrence of erratic boulders in the valleys which branch from that of the Calder, as, for example, the

Colne. It is quite impossible that these could have come from the west; the river rises on the high moorlands of Millstone Edge and Holme Moss, nearly 2000 feet above the sea-level, and falls rapidly to its confluence with the Calder at about 200 feet above the sea-level.

Some other peculiar circumstances may possibly be accounted for if we suppose the land to have been submerged to about 400 feet lower than its present level, and at the same time these facts act reciprocally in affording evidence that such was really the case. There are numerous beds of gravel and well-rounded boulders, composed entirely of rocks of local origin, millstone grit, flagrocks, pieces of coal, and the harder shales, and, where the peculiar siliceous sandstone called Calliard occurs in the vicinity, it is found in the gravel or drift. These beds occur on the hill-sides bounding the valleys, and generally at a height of 350 feet, a little more or less, above the present level of the sea. Examples may be seen at Kirklees Park, near Mirfield, at Exley, in the Elland Cemetery, at Mytholm, in a branch valley west of Halifax, and in other places as far westwards as Hebden Bridge. These gravels are quite distinct from those in the bottom of the valley, and are usually found occupying a plateau formed by a gritstone, from which the softer superincumbent shales have been denuded. In each of the situations cited above they are at least a hundred feet higher than the present level of the valley. Where exposed in section, they are current bedded, with thin layers of sand intermixed, and present every appearance of having been subjected to tidal action. The presence of these beds has been accounted for in a variety of ways; but the one I now suggest—that they were the shores of the old sea—perhaps appears the most reasonable, when considered in connexion with the drift deposits filling up the base of the valley. If they are the remains of the shores of an old lake, as some authors have described them to be, there remains the difficulty of damming up the waters to so great a depth, which does not appear probable, and of which there is no evidence at present existing.

In conclusion, the evidence that the erratic boulders in the valley of the Yorkshire Calder were derived from the sources so plentifully supplied in the great valley occupying the whole of the centre of the county, rather than from the district westwards of the summit of drainage, appears conclusive. In the one case we have the source of the Calder bounded by a series of hills rising to a height of 1,500 feet or more, and the only openings being at Calder Head on the northern and at Hollingworth on the southern part of the Chain. In either of these the land rises rapidly from the Lancashire side to the height of 610 feet and 700 feet respectively, and in each case they form the summit of drainage. All evidence proves that the general form and direction of the valleys remains unchanged since pre-glacial times, and this being so, the ordinary action of rivers being the agent which has carried the boulders from the Lancashire districts over the summits of drainage may be dismissed as out of the question, and, along with it, the theory of some of the early geologists, of a great wave of translation which was supposed to have swept across the Atlantic to our shores, and was made answerable for every unaccountable phenomenon in surface geology presented to their notice. A more probable theory is, that they were carried over by icebergs, but this necessitates that the land be submerged to the depth of 700 or 750 feet, and if that be granted, there can be no reason why the ice-floes should not have been occasionally stranded on some of the higher lands below the level of the water, and there have left evidence of their presence in heaps of travelled boulders, as well as in the lower parts of the valley; but such evidence is entirely wanting.

On the other hand, the glacial clays are extended across the mouth of the Calder, and the boulders derived from them may have been washed into the valley, during a slight submergence, by the action of the tides and waves and also borne up the valley by ice-floes. The statement of Prof. Green that a glacier at one time extended as far south as Barnsley, and left its detritus spread over the country northwards, furnishes a source for the boulders actually within the valley of the Calder as far west as Wakefield, and during the denudation of this district by marine action, the boulders would be naturally washed into the sheltered bay which the valley under those circumstances would form. It is not necessary that the land should be submerged more than 250 or 300 feet; but if it was lowered to the extent of about 350 feet, there is evidence of its former presence in the beds of sand and gravel which are found in many places on the hill-sides at a nearly uniform height above the sea-level.

NOTICES OF MEMOIRS.

ROYAL SOCIETY OF LONDON, MAY 1ST, 1879.

ON THE ORIGIN OF THE PARALLEL ROADS OF LOCHABER, AND THEIR BEARING ON OTHER PHENOMENA OF THE GLACIAL PERIOD. By JOSEPH PRESTWICH, M.A., F.R.S., F.G.S., etc., Professor of Geology in the University of Oxford.

A PAPER bearing the above title was read before the Royal Society on May 1st, in which the author gave a fresh interpretation to these well-known terraces. He commenced by stating that of the various hypotheses that have been brought forward since the time of Macculloch and Dick-Lauder to account for the origin of the Parallel Roads of Glen Roy, the one so ably propounded by Mr. Jamieson, in 1863, has been most generally received and adopted. It is a modification of the views originally expressed by Agassiz, to the effect that the barriers of the lakes—to the shore action of which both the above-named geologists attributed the "roads," but were at a loss to account both for the formation and removal of barriers—had been formed during the Glacial period by glaciers issuing from Glen Treig and Glen Arkaig, supplemented by others from Ben Nevis. The subsequent determination, by the Scotch geologists, of an intermediate milder period succeeded by a second cold period, led Mr. Jamieson, with whom the preglacial and glacial deposits of Scotland had been a subject of especial investigation, to conclude that the extension of these two glaciers took place during the second cold period, which he thinks was of little less intensity than the first, and that, while the glacier from Glen Arkaig blocked up Glen Gluoy, the glacier from Glen Treig formed a barrier to Glen Roy. He observes, "Grant, then, these two ice-streams, one in the Great Caledonian Valley and the other at Glen Treig, and the problem of the Parallel Roads can be solved, provided we allow that glaciers have the power to dam such deep bodies of water as must have occupied Glen Gluoy and Glen Roy."

Mr. Jamieson, in support of this view, adduces the extensive glaciation apparent at the entrance both of Glen Arkaig and of Glen Treig, and shows that near the entrance of Glen Gluoy there are ice striæ, pointing W. 5° N., or in the direction that a glacier coming from Glen Arkaig would take, and that, in the Spean Valley, opposite Glen Treig, the ice striæ are transverse to the valley, or in the direction of the axis of Loch Treig, while on either side they point respectively up and down Glen Spean. He infers, consequently, that the central portion of the glacier ascended the opposite hill to the Col of Glen Glaster, while one branch passed down the valley blocking Glen Roy, and another branch travelled up the valley eastward to the Pass of Makoul, and thence into the valley of the Spey.

The "roads" were, he considers, formed by long-continued shore action at each successive level of the lake, that level being determined by the height of the cols over which the lake waters escaped. In proof of the long duration of the lakes, Mr. Jamieson refers to the great extent of the "roads," and the large size of the mounds at the junction of Glen Turret and Glen Roy, and of that at the entrance of the Gulban in Glen Spean, which mounds he considers to be deltas formed by the respective streams flowing into the old lakes.

The author passed in review the opinions of Mr. Milne-Home, Prof. Nicol, Sir John Lubbock, Macculloch, Chambers, and other geologists, and whilst objecting to the hypothesis advanced by Mr. Jamieson, he considers that that theory affords the most satisfactory solution of the problem, only that he would suggest a different interpretation in explanation of the phenomena.

Dismissing the hypothesis of local glaciers of the second period of glaciation, the author falls back upon the original idea of Agassiz with the development acquired by more recent research, and assigns the Lochaber lakes to the close of the first period of great glaciation. He considers the phenomena are due to the peculiar physiographical conditions of the district, and shows that, owing to the configuration of the country, the drainage of the Ben Nevis range, instead of flowing off from the centre to two or more sides, is diverted to the north side only, because the two streams which receive the southern drainage, not only of Ben Nevis, but also part of that of the range of hills to the south of Ben Nevis, after flowing respectively east and west, turn nothward and debouche — one through Glen Treig and the other through Glen Nevis, into the lower part of the Spean Valley and the Great Glen near Fort William. These conditions, which now give this area an excess of water drainage, must in the like manner, during the Glacial period, have there led to an exceptional accumulation of ice.

With the incoming of this Glacial period, local glaciers must have descended from every mountain range, and so long as the glacier of one steep glen became confluent with another of the same chain flowing in the same general direction, so long would their course be uninterrupted, and the propelling and abrading force maintained, as in the Alps at the present day; but when, emerging from these glens into valleys of small gradients dividing the several mountain chains, they met with glaciers descending from these other ranges, their progress was not only subject to be checked, and their forces neutralized, but their course diverted, for if the lines of natural drainage were barred, the ice took those of least resistance, although such might be up-hill and against the lines of drainage. This, however, could not be effected without excessive pressure and heaping up of the ice at the points of junction.

These interferences must have been especially frequent in the valley of the Spean. On the one side, the glaciers descending the steep ravines of Larig Leachach, the Cour and others, adjacent on the northern flank of the Ben Nevis range, would issue into Glen Spean and project across it to the Glen Roy hills opposite. Below to the west, the great Nevis Glen glacier emerged into the valley of the Lochy, while above to the east the great glacier, issuing from Glen Treig, would flow down Glen Spean; but, meeting with the aforesaid group of glaciers from Ben Nevis, was partly diverted over the flanks of Craig Dhu, and upon the entrance to Glen Roy.

While the glaciers from this system of mountains were becoming confluent in and filling Glen Spean, those from the opposite range of hills were descending Glen Roy, Glen Feitheil, the Rough Burn, and the other ravines of that chain, and coming into collision with those of the Ben Nevis range. In the same way, the valley of Loch Eil, Glen Nevis, Glen Mhuilinn, Glen Loy, and others were focussing their glaciers upon the end of the Great Glen north of Ben Nevis, barring in that direction the passage of the ice down Glen Spean, and diverting it northward towards Loch Lochy and Loch Oich.

Therefore, the great mass of ice descending Glen Spean, in consequence of meeting with these obstructions, was driven to accumulate in mass in the lower part of that valley opposite Glen Roy, until, overcoming further resistance and confluent with the Ben Nevis mass, it wheeled round into the Great Glen at Loch Lochy, where the united stream found not only a more contracted passage, but, meeting also at right angles the glacier issuing from Glen Arkaig, was forced against and up the entrance to Glen Gluoy opposite.

The author then points out the many mounds and terraces in the Spean Valley formed of moraine detritus, though since levelled and often masked by a covering of gravel due to subsequent water action. To this cause also he attributes the large accumulation of *débris* at the entrance to Glen Roy, between Bohuntine and Glen Glaster, where he shows it to be in places 200 or 300 feet deep and to consist of a light grey argillaceous unstratified matrix with angular fragments of the local rocks capped by stratified gravel. The mass rises nearly to the level of the lower parallel road.

The author next discussed the height of the land in relation to the sea at the period of the great glaciation, and he sees reason to conclude that the land then stood at not less than from 1000 to 1500 feet higher than at present, so that the Irish Channel was then above the sea-level, and land extended a considerable distance westward from the present coast of Scotland.

This was followed by a submergence of not less than 1200 to 1500 feet in central and northern England, Wales, and Ireland, and of 600 feet in the southern part of Scotland, as proved by the occurrence of marine shells at those heights.

The influence of difference in level upon climate was next discussed, and its effect was stated to be, probably, not less than from 12° to 15° F., which is about equivalent to the difference of climate between Paris and St. Petersburg.

It is well known that the Parallel Roads are terraces composed of perfectly angular fragments of the local rocks with a few rounded pebbles, both local and foreign to the district. The former show an entire absence of any prolonged beach wear. The wear of the latter is due to other causes. There is also an entire absence of any notch or cliff line such as would be due to the wearing back of a shore line, and of any projecting ledge such as would result from the throwing forward of the shore *débris*. The slope of the hills above and below the "roads" varies from 25° to 40°, and the inclination with the horizon of the "roads" themselves, which are from 50 to 70 feet wide, varies within the limits of from 5° to 30°.

Although therefore the "roads" indicate a line of water-level, there is nothing in their form or structure to show that they have been formed by the long-continued action of lake waters on a shore line. To what then are they to be ascribed?

The first or highest "roads" is confined to Glen Gluoy, the second and third to Glen Roy, and the fourth or lowest to Glen Roy and Glen Spean. What the conditions were immediately antecedent to the formation of the first, second, and fourth road, is not shown; but in the case of the third road, the conditions preceding its formation are to be traced uninterruptedly from the conclusion of No. 2 "Road." When the lake stood at the level of "Road" No. 2, its waters escaped by the col leading to Glen Spey, while when they stood at the level of No. 3 "Road," they escaped by the Glen Glaster Col. Now as there is a difference of 76 feet between the height of the two cols, it is evident that a barrier must have existed on the latter col during the time the lake stood at the higher level. Whether the barrier was detrital or ice-formed is immaterial for the argument. In both cases, either by gradual weathering or melting, the time would come when the barrier would be lowered in some place to the level of the lake.

Now, it is well known to engineers that a breach once established in a detrital barrier becomes so rapidly enlarged that, if not at once stopped, nothing can stay the rapid destruction of the barrier, as in the case of the Holmfirth, Crinan, and other floods. Nor is evidence wanting of similar catastrophes in connexion with glacier lakes. In the notable case of the Gietroz Glacier barring the valley of the Drance, a lake was formed which attained a length of nearly two miles, and a depth at the barred end of 200 feet. So rapid was the discharge when the barrier yielded, that the lake was drained in twenty minutes. The still greater flood recorded by Vigne, which descended a branch of the Indus in one day for a distance of 125 miles, has since been shown by Mr. Drew to have been caused by the bursting of a detrital barrier formed by a landslip. In consequence of this a lake had been formed, which he estimates to have been 35 miles long by one mile broad and 300 feet deep at its lower end. The whole was drained in a day.

In the same way, it is to be assumed that the Glen Glaster barrier, which was probably formed by a remnant of the glaciers descending from the mountain ranges (2,994 feet) at the head of the glen, at last gave way with great suddenness, and caused the rapid fall of the waters from the level of the higher "road" in Glen Roy to that of that Glen's second "road," at the height of the Glen Glaster Col, when the escape of the waters was stopped.

Now, it must be borne in mind that, at this time, the great mantle of snow and ice which had so long covered the country, was passing away, leaving the surface of the hills in Glen Roy covered with a thick coating of angular local *débris* mixed with sand and clay, the result of the intense cold and of the decomposition of the underlying schistose and granitic rocks. This and the glacial *débris* must have long remained bare and unprotected by vegetation; at all events, that below the water-line was so. Now, the angle of repose of purely angular and subangular *débris* varies within the limits of from 35° to 48°, but that of clayey sands, which when dry is from 21° to 37°, becomes, when saturated with water, as low as 14° to 22°. The angle of repose of the hill-side *débris* would, therefore, depend on the relative proportion of the angular materials and their matrix, and on the extent of saturation. The slopes of the hills being on the whole greater than that of the angle of repose of the saturated under-water rubble, this latter, easily set in motion owing to the settlement of its constituent parts as the water drained from it would, as the level of the lake water fell, tend to slip or slide down with the falling water, and this slip would continue until the disturbing cause ceased, and the momentum of the mass was checked by the inertia of the water gradually coming to rest on reaching the level of the col of escape. The effect of the arrested slip, combined with the state of maximum saturation of the mass, would be to project it more horizontally forward, and form a ledge. This ledge, modified slightly by subsequent subaërial action and weathering, and by the dressing of its slope on the occasion of the next fall of the lake, constitutes the "road."

Although in the case of the other "roads" there is not the same evidence of a minor col-barrier, as the results are alike in all, the causes which led to them must have been the same; and it is shown that there is nothing incompatible in the features of the ground with the existence of such barriers, or rather that there is some evidence in each glen, however slight, of water lines at levels higher than the "roads." There are difficulties in the way of the lower "road," No. 4, which extends through Glen Roy and Glen Spean, that need discussion, but they are not considered more serious than these which attend the other hypothesis.

This is followed by a discussion on the Till; on the parallelism of the Roads; and the general conclusions drawn by the author from the phenomena in Lochaber and the surrounding district.

REVIEWS.

I.—The Gault, being the Substance of a Lecture Delivered in the Woodwardian Museum, Cambridge, 1878, and before the Geologists' Association, 1879. By F. G. Hilton Price, F.G.S. (London, Taylor and Francis, 1879.)

FEW formations have received a larger share of attention of late years than the Gault, and this may be partly due to the extensive exploitation of the Cambridgeshire Phosphate-bed, whose organic remains have been so largely derived from its denudation.

As the Upper Cretaceous geology of England has been much studied by French geologists, and especially by Dr. Barrois, the Gault and its equivalents have naturally come in for close scrutiny, and the French classification differs somewhat from that usually adopted in this country. Much of this misunderstanding arises from our using the lithological term "Gault," originally a Cambridgeshire provincialism, for all the blue and grey marly clays at the base of the Chalk, whilst the similarly situated glauconitic sands and other beds have been called Upper Greensands, Red Chalks, etc.

For purposes of mapping, and for economic geology, this is by far the best plan, and indeed the only one that could well be adopted, as the tracing of a merely palæontological line over a large extent of country where there is only an occasional exposure is practically impossible. The surveyor must therefore be guided in the main by the composition of the beds he is mapping; where all is clay, he may easily class two very different faunas under one denomination, whilst, on the other hand, as the composition changes, he will be apt to give beds more or less contemporaneous very different titles.

This is exactly what has happened in the case of the Gault in England. Nothing can be clearer, when, by the help of Mr. Price, we have studied the Folkestone section, which for many reasons must be deemed the typical one, that under the general term "Gault" are included two extremely different formations.

The one known as the Lower Gault consists of black clays, much subdivided by nodule-beds, and is remarkable for the abundance of its Gasteropoda, and grooved Ammonites, of which *A. interruptus* may be taken as the type. It is the equivalent of the Albien in part, and would seem to be more extensively developed in France than throughout England generally. Not a single Brachiopod is quoted from it in Mr. Price's Table. The minor subdivisions noted at Folkestone may be made out at Wissant, but it is not clear that such is the case as regards English localities generally. Westwards the clays of Black Venn probably belong to this zone, and it may be traced northwards for some distance beyond Cambridge, though hardly as far as Hunstanton. There is no palæontological evidence, according to Mr. Price's Table, for its existence further north.

This Albien, or Lower Gault, underwent in places an extensive denudation, of which at Folkestone Mr. Price's Junction or Nodule-bed is in part the evidence. Upon its remains was deposited the overlapping Upper Gault, which, under various lithological aspects —a grey marl with over 25 per cent. of carbonate of lime at Folkestone—a glauconitic and cherty sandstone in the West of England, a "red chalk" at Hunstanton and Speeton—forms the base of the Chalk throughout England, itself resting upon a variety of beds where the Lower Cretaceous rocks are absent. Keeled Ammonites are characteristic of this formation, and *A. inflatus*, as the most abundant and typical, gives its name to the group, which corresponds to the greater part of the Cenomanien. At Folkestone, Brachiopoda are tolerably plentiful, and wherever *Kingena lima*, *Terebratula biplicata*, and *Avicula gryphæoides* are congregated in abundance, we may feel sure that we are on this horizon, even if the characteristic Ammonite fail us for a time.

The student of Cretaceous Geology will find Mr. Price's publication most useful. The bibliography is brought up to date, and shows how much has been published within the last twelve years—a portentous accumulation, if the literature is to go on increasing in the same ratio. This is succeeded by a sketch of the hydrography of the period in North-west Europe, with an indication of the probable limits of the Anglo-Parisian basin at that time. A detailed description of the Gault of Folkestone follows, being the substance of the author's paper in the Q.J.G.S. for 1874, with the addition of new matter, and then a brief account of the Gault along its outcrop in the several counties from Kent to Yorkshire. A sketch of the Gault of France, with palæontological correlations, concludes about 40 pages of the text.

But it is the Table, occupying nearly 40 additional pages, which constitutes the chief value of Mr. Price's book. This enumerates about 800 species, exclusive of foraminifera, and is arranged in 20 principal columns as follows:—1. JUNCTION (basement bed) LOWER GAULT; 2. Folkestone, in vi. subdivisions; 3. Cambridge; 4. Wissant; 5 and 6. Zone of *Am. interruptus* in the Aube and Yonne. JUNCTION 7. Folkestone; 8. Nodules *à Epiaster Ricordianus* of the Ardennes and Meuse. UPPER GAULT 9. Folkestone in iii. subdivisions; 10. Cambridge, *derived*; 11. Speeton Red Chalk; 12. Hunstanton Red Chalk; 13. Blackdown Greensand; 14. Wissant; 15. Ardennes, Meuse (fossiles en phosphate de chaux); 16. Ardennes, Meuse (fossiles en gaize); 17, 18, 19. Other localities in France; 20. Puttenham, Bucks.

W. H. H.

II.—Mémoire sur le Terrain Crétacé des Ardennes et des régions voisines. Par le Dr. Charles Barrois.

[Extrait des Annales de la Soc. Géol. du Nord, tome v. pp. 227–487, Lille, 1878.]

There exists no more indefatigable a labourer in the cause of geological science than Dr. Barrois, for not only has he carried his observations into many formations and over an extended area, but his works are always characterized by a scrupulous care to do credit to every previous observer in the branch of inquiry which he takes up. The present work contains a description of the Cretaceous rocks forming part of the Paris Basin, in a department situated to the north-east of France. It embraces accounts of the Aptian, Albian, Cenomanian, Turonian, and Senonian strata, known more familiarly to us as Lower Greensand, Gault, Upper Greensand, Lower and Upper Chalk, respectively.

Full descriptions, and lists of fossils from the several formations are given, and comparisons are made with beds developed in other districts.

The following is a summary of the divisions described :—

Senonian.	Bed with *Belemnitella.*	Chalk of Epernay with *Belemnitella mucronata.* Chalk of Reims with *Belemnitella quadrata.*
	Bed with *Micraster coranguinum.*	Magnesian Chalk with *Marsupites.* Magnesian Chalk with *Inoceramus involutus.*
Turonian.	Bed with *Micraster breviporus.*	Chalk of Vervins with *Epiaster brevis.* Chalk rock with *Holaster planus.*
		Marl with *Terebratulina gracilis.* Bed with *Inoceramus labiatus.*
Cenomanian.	Upper.	White Marl of Argonne and glauconitic marl of Thiérache with *Belemnites plenus.* Marl with *Ammonites laticlavius.*
	Lower.	Sands of Hardoye. Marl of Givron. } Zone of *Pecten asper.* Zone of *Ammonites inflatus.*
Albian.		Zone of *Epiaster Ricordeanus.* Phosphates of Talmats. Bed with *Ammonites interruptus.* Bed with *Ammonites mammillaris.*
Aptian.		Clay and Sands with *Ammonites milletianus, Ostrea arduennensis.* Ironstone of Bois-des-Loges.

H. B. W.

REPORTS AND PROCEEDINGS.

Geological Society of London.—I.—May 14, 1879.—Prof. P. M. Duncan, M.B., F.R.S., Vice-President, in the Chair.—The following communications were read :—

1. "Further Observations on the Pre-Cambrian Rocks of Caernarvon." By Prof. T. M'Kenny Hughes, M.A., F.G.S.

The author divides these into (1) the volcanic series, (2) the felsitic series, (3) the granitoid series. He traces the former of these, consisting of coarser and finer varieties, from Caernarvon to near Port Dinorwig. Beyond these come the felsite series, which is overlapped by grits and conglomerates as far as the Bangor road, N.E. of Brithdir.

Above the latter comes the "volcanic series," well developed in the neighbourhood of Bangor. The author is of opinion that the Cambrian conglomerate, with associated grits, may be traced in the edge of the older *massif* from Twt Hill, Caernarvon, to Garth Point, Bangor, and that the beds in each of these places and near Brithdir, recently described as separate, are identical; also that the bed with purple fragments near Tairffynnon and the Bangor Poorhouse are only Cambrian conglomerate faulted down. Further, he considers that the strata of the above three series are fairly parallel throughout, and that they only form three subdivisions of one great series.

2. "Notes on the Structure of the Palæozoic Districts of West Somerset." By A. Champernowne, Esq., F.G.S., and W. A. E. Ussher, Esq., F.G.S.

The authors confirmed the general accuracy of Mr. Etheridge's views as to the structure of North Devon and West Somerset, but differed from him in ascribing the limestone of Cannington Park to the Carboniferous, both on account of lithological character, the fossils in Taunton Museum, said to be obtained from it, and the latitude of its position with reference to the Carboniferous Limestone of the Mendip, South Wales, and the steep and flat Holmes. They described four traverses made by them in West Somerset. 1st. From Dulverton to Dunster, in which, proceeding northwards, the following beds were encountered:—Culm-measures faulted against Pilton Beds (Upper Devonian), Pilton Beds faulted against Pickwell Down Sandstone (base of Upper Devonian), Pickwell Down Sandstones becoming slaty in passing into Morte slates (Middle Devonian) and troughed in them by faulted synclines, Morte slates passing into Ilfracombe slates (overlying Hangman grits) near Cutcombe, Hangman Grits, evidently faulted against Foreland grits, as no representative of the Lynton beds is present between Oaktrow and Timberscombe.

In traverse 2, the fault between the Hangman and Foreland grits is proved by the presence of the Lynton beds in the valley west of Luccot Hill and their conformable infraposition to the Hangman series, and abrupt termination by fault against the Foreland grits of Porlock and Oare Hills. At Oare a patch of schist of the Lynton zone was noticed resting on the Foreland grits on the north side of the fault.

The 3rd traverse in the Tone valley gave the following succession of beds:—Culm-measures on Pilton beds; Pilton beds with grits, much flexured, on Olive slates with *Lingula* and grits with *Cucullæa*, conformably overlying Pickwell Down grits, which make a conformable junction (following the feature) with the underlying quartziferous slates of the Morte series (Middle Devonian); the latter were observed between Huish Champflower and Clatworthy; but, as the Middle Devonian slates appear to extend considerably northward in the Brendons, they were not traversed beyond Clatworthy.

The 4th traverse from West Quantockshead to Cannington Park proved the composition of the Quantocks along that line to be grits, in places associated with schistose shales, apparently belonging to the Hangman series (Middle Devonian); whilst the Palæozoic inliers, in the Triassic area of Bridgewater, are unlike the Quantock rocks in character. The limestones of Asholt and Hollwell, associated with slates of the Ilfracombe series, are very similar to varieties of the South Devon limestone, and are quite unlike the limestone of Cannington Park.

3. "The Whin Sill of Teesdale as an Assimilator of the surrounding Beds." By C. T. Clough, Esq., F.G.S.

Owing to the general absence of mechanical disturbance, the author is of opinion 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." He proceeds to describe sections at Caldron Snout, Cronkley Fell, Noon Hill, etc., which seem to him inexplicable on any other theory. The author discusses objections on chemical grounds, holding that the general uniformity in chemical composition of the Whin may be explained by supposing the absorbed beds to have permeated a large mass of the Whin, as an alloy does melted metal. He thinks the explanation may be extended to other intrusive masses.

4. "On the Silurian Rocks of the Valley of the Clwyd." By Prof. T. M'Kenny Hughes, M.A., F.G.S.

The author gives a preliminary sketch of the Silurian rocks of the southern and western part of the Clwyd valley. He describes first some beds below the horizon of the Denbigh Grits at Ffriddfawr which agree very well in their characters with the base of the Coniston Grit, and others near agreeing with the passage-beds between these Grits and Flags. He next describes sandstones in the Clywedog valley, the equivalents of the lower Grits; and lastly, at Bod Renail, flags, etc., the Pale Slates, which contain Graptolites, and are thus to be identified with the Graptolitic mudstones of the Lake-district. Thus he is of opinion there is a basement-series here for the Silurian, corresponding in all its details with that in the Lake-district.

II.—May 28, 1879.—Henry Clifton Sorby, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Endothiodont Reptilia, with evidence of the species *Endothiodon uniseries*, Owen." By Prof. R. Owen, C.B., F.R.S.

The author referred to the characters assigned by him to his *Endothiodon bathystoma*, which had the alveolar borders of both jaws toothless, perhaps covered with horn during life, as in the Chelonians; whilst within this border there were three series of teeth both in the palate and the mandible. He next described a new species, under the name of *Endothiodon uniseries*, founded upon the fore half of a skull, having only a single row of teeth in the palate, a character which may prove to be of generic importance. The author finally discussed the relationships of this genus, which he regarded as belonging to the order Anomodontia, and as showing, like *Oudenodon*, traces of derivation from *Dicynodon* in the presence of caniniform processes in the upper jaw. The development of teeth interior to the alveolar margins in both jaws was to be regarded as a character of family value, and the author remarked upon the interest of the continuance of a common Ichthyic and Batrachial dental character in exceptional cases among the Reptilia up to the establishment of the Crocodilian type, above which, in the vertebrate series, calcified palatal teeth no longer appear.

2. "Note (3rd) on *Eucamerotus*, Hulke, *Ornithopsis*, Seeley, = *Bothriospondylus magnus*, Owen, = *Chondrosteosaurus magnus*, Owen." By J. W. Hulke, Esq., F.R.S., F.G.S.

In this paper the author gave a description of an unusually perfect dorsal vertebral centrum of *Ornithopsis*, and some additional information respecting the cervical and anterior dorsal vertebræ. He further compared the prosacral vertebræ with those of several recently discovered Dinosaurians of the Colorado region, showing several agreements, but also such differences as to prove the generic distinctness of *Ornithopsis*. He discussed the question of the nomenclature of the species indicated in the title of his paper, and maintained that the name *Ornithopsis* ought to be adopted for the single genus to which he referred them.

3. "Description of the species of the Ostracodous genus *Bairdia*, M'Coy, from the Carboniferous Strata of Great Britain." By Prof. T. Rupert Jones, F.R.S., F.G.S., and James W. Kirkby, Esq.

The long persistence of the genus *Bairdia*, from the Silurian period to the present day, and its essentially *marine* character, were first noticed; also the relatively rare occurrence of any species of *Leperditia*, *Beyrichia*, and *Kirkbya* (associates of *Bairdia* in Carboniferous strata) in freshwater or estuarine beds. *Carbonia*, on the other hand, was confined to the fresh or brackish waters in which the Coal-measures were formed. The difficulty of defining the species of *Bairdia* from carapace-valves alone, without limbs and soft parts, and the possibility of several genera being grouped under this head, were mentioned. The species of *Bairdia* described and figured in this paper were, it is believed, all that have been found in the British Carboniferous rocks, with the exception of M'Coy's *B. gracilis*. Two of Count Münster's Bavarian *Bairdiæ*, from Hof, have not yet occurred with us; neither have four of Dr. D'Eichwald's Russian Carboniferous species, nor the Australian *B. affinis*, Morris. Including these, there are twenty-three known Carboniferous species of *Bairdia*. Seven of these are recurrent in the overlying Permian limestones, which have yielded twelve species of this genus. With six Silurian forms, there are altogether thirty-four recorded Palæozoic species of *Bairdia*.

4. "Report on a Collection of Fossils from the Bowen River Coal-field and the Limestone of the Fanning River, North Queensland." by R. Etheridge, Esq., jun., F.G.S.

The collection on which the present paper was founded had been received from Mr. R. L. Jack, F.G.S., and the information furnished by it was supplementary to that obtained from Daintree's collection. The fossils are from three distinct horizons. The author first briefly described the geology of the formations from which the fossils were derived, and stated that the results of his investigations led him to refer those from the Fanning River Limestone to the Devonian, those of the Bowen River Coal-field to the Upper Carboniferous or Permo-Carboniferous, and those from the Tait River to the Cretaceous. Twenty-six species of animal remains, chiefly Mollusca, are described in all, twenty of which are from the Bowen River Coal-field; the latter include a fine series of *Strophalosiæ*. The new species are *Protoretepora Koninckii* from the Permo-Carboniferous of Bowen River, and *Crioceras Jackii* from the Cretaceous; also *Strophalosia Jukesii* from the Carboniferous of New South Wales. The paper included a list of the localities in which the specimens were collected, and a full bibliography of Queensland palæontology.

5. "On a Fossil *Squilla* from the London Clay of Highgate, part of the Wetherell Collection in the British Museum." By H. Woodward, Esq., LL.D., F.R.S., F.G.S.

The specimen described is preserved, as usual, in a phosphatic nodule, and exhibits five well-preserved abdominal segments (XIV.–XVIII.), a portion of the carapace, traces of the thoracic appendages, and the appendages of the twentieth segment preceding the telson. The abdominal segments increase in breadth posteriorly as in modern *Squillæ*. The species is most nearly allied to a recent Australian *Squilla* (unnamed) related to *S. Desmarestii*. The author proposed the name of *Squilla Wetherelli* for the London-clay fossil.

6. "On *Necroscilla Wilsoni*, a supposed Stomatopod Crustacean from the Middle Coal-measures, Cossall, near Ilkeston, Derbyshire." By H. Woodward, Esq., LL.D., F.R.S., F.G.S.

The specimen described was found by Mr. E. Wilson, of Nottingham, in a nodule of Clay-ironstone. It consists of the four posterior abdominal somites and the telson. The author discussed its zoological characters, which led him to regard it as approaching the Stomatopoda rather than the Isopoda. He thought it probable that Dr. Dawson's *Diplostylus* is allied to this newly-discovered form, for which he proposed the name of *Necroscilla Wilsoni*.

7. "On the Discovery of a Fossil *Squilla* in the Cretaceous Deposits of Hâkel, in the Lebanon." By H. Woodward, Esq., LL.D.

This fossil *Squilla* occurs in a collection, chiefly consisting of fossil fish, but also including several Crustacea and some beautifully preserved Cephalopods, obtained in the Lebanon by Prof. E. R. Lewis, of Beirût. The specimens are in a compact cream-coloured limestone, most of the slabs of which contain examples of *Clupea brevissima* and *C. Bottæ*, fragments of *Eurypholis Boissieri*, and other fishes. Like the London-clay form, the species seems to be most nearly allied to the Australian species collected by Prof. Jukes, the segments are not ornamented with spines and ridges. The author proposed for it the name of *Squilla Lewisii*.

8. "On the Occurrence of a Fossil King-Crab (*Limulus*) in the Cretaceous Formation of the Lebanon." By H. Woodward, Esq.

This was another of Prof. Lewis's discoveries, and was of much interest as helping to bridge over the interval between the Jurassic *Limuli* of Solenhofen and those now living. The author described the characters presented by the single specimen, for which he proposed the name of *Limulus syriacus*.

CORRESPONDENCE.

JUKES ON RIVER VALLEYS, S. W. CORK.

Sir,—In reply to Mr. A. J. Jukes-Browne's letter in the Geol. Mag. for May, 1879, I would point out that the apparent discrepancy between the statements in "Valleys and their Relations, etc.," and in the "Geology of Ireland," is easily explained. In the first, the statement refers to the formation of valleys in any country and in any kind of rocks; while in the second, the statement refers solely to the valleys of S. W. Cork. Such a general statement as the first would not refer to a peculiar country like S. W. Cork, where the Carboniferous slate rocks are as hard and are as capable of resisting denudation as the Old Red Sandstone, while if Coal-measures once existed in the synclinal troughs, they probably were also indurated and similar to the rocks that form the hills immediately north of the Black Water Valley and hills elsewhere in South Ireland.

Jukes distinctly states that the Carboniferous slate was once covered by limestones, while subsequently he relies on the soft nature of the limestone to expedite the formation of his valleys.

I cannot exactly see why this theory has a claim to be called "well considered." When put forward, it was founded on suppositions that were then questioned, and which have since been shown to have been too hastily arrived at. It also ignores all faults and dislocations of strata in the different areas mentioned, while originally it totally ignored ice-action. It was only an afterthought, to bridge over the last, that the statement "a glacier is only a frozen river" was introduced; but this does not meet the objection, as the actions of moving frozen and unfrozen waters are very different.

I do not for a moment presume to say that in no place could rains and rivers produce the effects described; but as the theory was founded in a country and on suppositions which were afterwards found to be erroneous, I think I am justified in saying the general theory "falls to the ground." G. H. Kinahan.

Ferns, *May* 13, 1879.

DEVON GEOLOGY.

Sir,—From the Rev. H. H. Winwood's letter, Geol. Mag. May, 1879, it would appear that my statement casts a slur on the Devonshire Amateur Geologists; for this I am extremely sorry, as such was never my intention, the remarks being intended solely to refer to a paper which I believe has been given much more importance to than it merits. I can assure Amateurs that I look on them with great respect, and I sincerely wish there were more of them in Ireland, as they are the only safeguard against the overwhelming vagaries and egotism of the "Trained Geologists"; and I would have much more respect for them if sometimes they were more independent, as they often allow their well-worked-out results to be snuffed out by individuals whose only claim to be heard is that they are officials.

I regret I cannot accept my friend's hospitable challenge for various reasons; because I have given up "coat strealing," and principally that I cannot devote sufficient time to be such a master of the Devonian sections as would give me a claim "to beard the lion in its den." I must, however, say that if the Devon geologists are satisfied with the evidence brought forward to refute the existence of Jukes's, or rather De la Beche's fault, they are very easily satisfied.

Various Irish geologists have gone to Devon, Cornwall, and Wales, to compare the Irish and the English rocks; yet how many of them have written on the English rocks? I do not know of any English geologists except De la Beche (who we may nearly claim as an Irish geologist) who have examined the Irish rocks, further than taking a hurry scurry on a car through the country, yet we are coolly asked to squash the work of years to suit these ideas. Who therefore,—English or Irish,—take the cross channel view of the rocks? G. H. Kinahan.

Ferns, *May* 13, 1879.

BEEKITE IN THE CHANNEL ISLANDS.

Sir,—Will you allow me to add to Capt. Jamieson's interesting account of his discovery of Beekite in the Punjab, contained in the last Number of the Geological Magazine, that this mineral also occurs in a Triassic conglomerate in Bouley Bay, Jersey, described in Ansted and Latham's "Channel Islands," p. 274.

A year or two ago I picked up several specimens on the beach there in pebbles containing corals and shells. Thus the range of Beekite in Europe is slightly extended beyond the shores of Torbay.

It would be interesting to know if the same conglomerate with Beekite also occurs in Normandy, among the rocks believed by Mr. Ussher to be a south-easterly extension of the Triassic beds of Devonshire (see "On the Triassic Rocks of Normandy, etc.," by W. A. E. Ussher, Esq., F.G.S., Quart. Journ. Geol. Soc., vol. xxxv. p. 245). J. A. Birds.

82, Gloucester Terrace, Hyde Park,
June 4, 1879.

P.S.—There is a specimen of Beekite in the British Museum, from Vallecas, near Madrid.

BEEKITE IN FLINTSHIRE.

Sir,—Capt. Jamieson, in his letter on Beekite from the Punjab, in the Geological Magazine of last month, mentions Torbay as the only known locality in Great Britain for this mineral. It occurs also in the Carboniferous Limestone of Flintshire, and in every specimen that I have hitherto met with as a crust replacing the shell of a *Productus*. The siliceous gangue of many of the veins and the silicification of the *Encrinites* and other fossils in the Limestone in and near such veins is a further indication of the passage of water containing silica in solution. A. Strahan.

Holywell, 18*th June*, 1879.

THE DISCOVERY OF UPPER SILURIAN ROCKS UNDER THE CHALK OF HERTFORDSHIRE.

Sir,—Allow me to call attention to the fact that the discovery of the Upper Silurian Rocks in Hertfordshire under the Upper Cretaceous—an account of which has been given by Mr. Etheridge, F.R.S., in *The Times*[1]—corroborates the views I stated as far back as 1861, in the second edition of 'The Coal-fields of Great Britain,' and again in the third edition of 1873. The little ideal section, by which I intended to show the structure of the central and eastern counties, represents (p. 475) the "Silurian and Cambrian" rocks as underlying the Cretaceous in the part of the country corresponding to Hertfordshire. This ought to convince sceptics that geologists *can* see deeper than other men into a millstone.

Geological Survey of Ireland, Edward Hull.
Hume Street, Dublin.

OBITUARY.

JOSEPH WILSON LOWRY, F.R.G.S.

Born October 7, 1803. Died June 15, 1879.

Death has just erased another well-known name from the roll of workers on the Geological Survey of Great Britain—that of J. W. Lowry, the eminent engraver, whose maps, sections and plates of fossils form so interesting a part of the records of this important branch of the scientific public service.

Joseph Wilson Lowry was the only son of Wilson Lowry, F.R.S., and Rebecca Lowry, well known as a mineralogist some seventy years ago. His father was the leading architectural and mechanical engraver of his time, and he trained up his son to follow his own pursuits. From his early youth his father's house was the resort of men of high intellectual culture, and his mother's pursuits leading her also to associate with the scientific men of the day, what wonder that young Lowry early imbibed his parents' tastes, and became an ardent lover of all Natural History studies and pursuits, an accomplished draughtsman, and a well-informed scientific man.

His first practical effort was directed to the construction of a model in plaster of the Isle of Wight, geologically clooured, and divided transversely so as to give a section (also geologically coloured) through the centre of the island.

His pursuit of Natural Science led him early in life to become acquainted with John Phillips, at that time Keeper of the Yorkshire Philosophical Society's Museum in York, and later on, when Assistant-General-Secretary of the British Association for the Advancement of Science, and when associated with De la Beche on the Geological Survey, or when Professor of Geology in Oxford until his death, Prof. Phillips remained the attached friend of J. W. Lowry.

[1] See also Geol. Mag. 1879, for June, pp. 286—289, with a complete list of the fossils determined.

Lowry's first important work, as an engraver, was the execution of the plates for the Encyclopædia Metropolitana. He also executed for Sir John Rennie a series of plates of London Bridge. For many years Mr. Lowry prepared all the engravings for Scott Russell illustrative of wave-lines and the contours of Vessels. He also designed and executed numerous maps and charts for the Society for the Promotion of Christian Knowledge; the Atlas of Maps published by the *Dispatch* newspaper—the first really cheap and good atlas ever produced.

The plates illustrating Phillips's Geology of Yorkshire, Weale's Scientific Manuals, and many other educational and scientific works, were engraved by Mr. Lowry. We are indebted to Mr. Lowry for the excellent series of Natural History Charts of British Fossils Stratigraphically arranged; British Tertiary Fossils; Recent and Fossil Crustacea, by J. W. Salter and Dr. H. Woodward, etc., etc.

Hundreds of plates of fossils exquisitely engraved, and maps and sections too numerous to recount, published for the Geological Survey of Great Britain, amply testify to Mr. Lowry's rare ability as a scientific engraver. Even the familiar card-maps of each town visited year after year by the British Association were invented and produced by Mr. Lowry's skill and ingenuity.

But the days of engraving seem drawing to a close (at least so far as *printing* from engraved plates is concerned), but the beautiful plates prepared by Mr. Lowry cannot well be surpassed by modern lithography save in cheapness. His Geological and Natural History Charts, produced at great personal expense and labour, are still the best of their kind extant, and continue greatly in demand.

Much as Mr. Lowry's work was valued by scientific men, his amiability of disposition and his modesty won for him even higher esteem among his friends. Many who knew him personally will recall his readiness on all occasions, even at great personal sacrifices, to help those who needed his assistance. His freshness of heart and kindness to the young were marked features in his character, and endeared him to all.

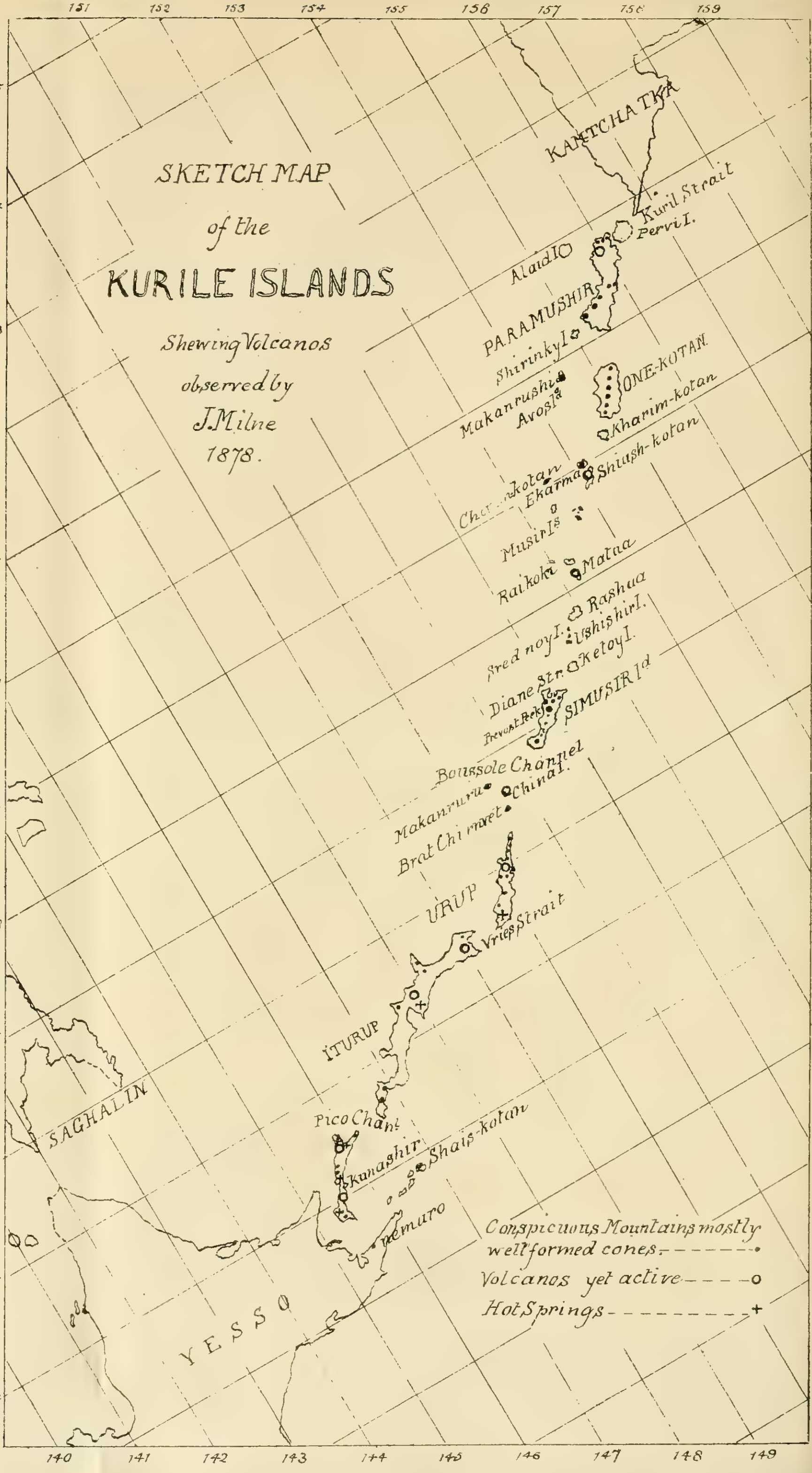
MISCELLANEOUS.

The Appointment of Registrar to the Royal School of Mines.—Mr. F. W. Rudler, F.G.S., who, from 1861 to 1876, held the office of Assistant Curator, under Mr. Trenham Reeks, to the Museum of Practical Geology, in Jermyn Street, and subsequently was appointed to the University College of Wales at Aberystwyth, has been duly appointed to succeed Mr. Trenham Reeks as Registrar of the Royal School of Mines and Curator to the Museum of Practical Geology. This appointment will afford great satisfaction to a large circle of scientific friends, by whom Mr. Rudler has long been known and highly esteemed.

[illegible] :Co.imp.

Emys lutaria *Merr. Mundesley, Norfolk.*

(See p. 306.)


SKETCH MAP
of the
KURILE ISLANDS
Shewing Volcanos
observed by
J. Milne
1878.
KAMTCHATKA
Kuril Strait
Pervi I.
Alaid I.
PARAMUSHIR
Shirinky I.
ONE-KOTAN
Makanrushi
Avos I.
Kharim-kotan
Shiash-kotan
Ekarma
Musir Is
Raikoke
Matua
Rashua
Ushishir I.
Sred noy I.
Ketoy I.
Diane Str.
Prevost Peak
SIMUSIR Id
Boussole Channel
Makanruru
China I.
Brat Chirnoet
URUP
Vries Strait
ITURUP
Pico Chanl.
Kunashir
Shais-kotan
Nemuro
SAGHALIN
YESSO
Conspicuous Mountains mostly well formed cones
Volcanos yet active
Hot Springs
151
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158
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140
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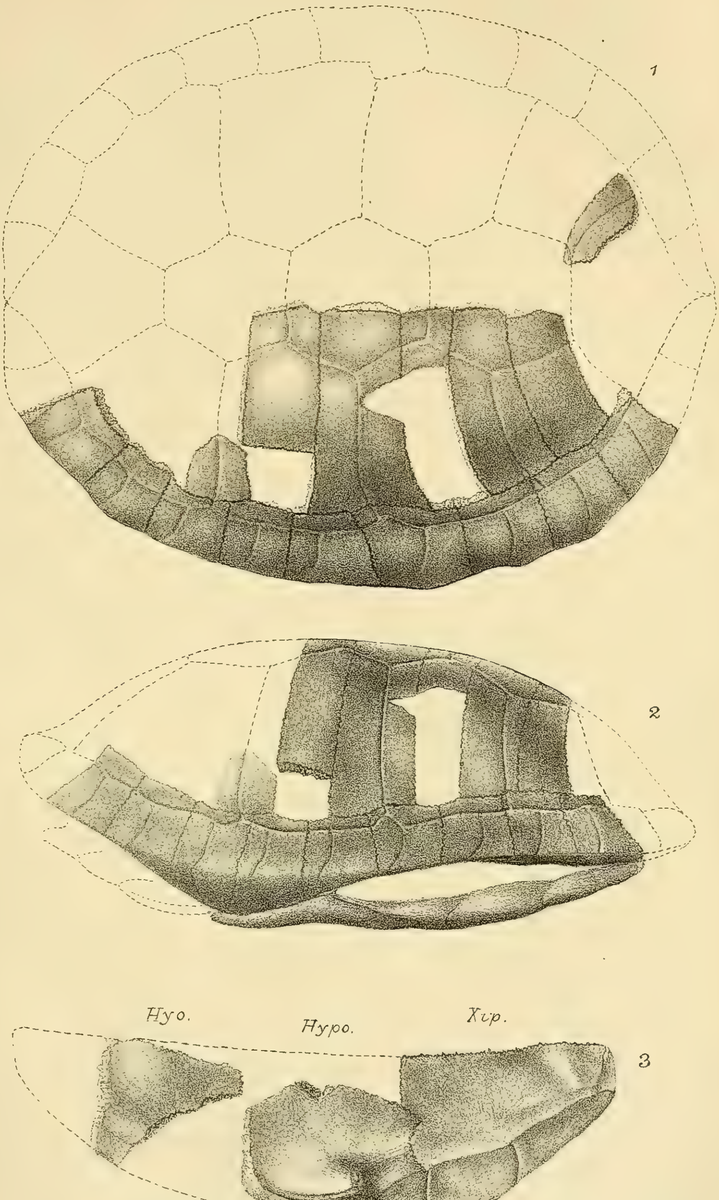

H. Knight lith. West. Newman & Co. imp.

Emys lutaria *Merr. Mundesley, Norfolk.*

(*See p. 306.*)

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ORIGINAL ARTICLES.

I.—A Cruise among the Volcanos of the Kurile Islands.

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(PLATE IX.)

THE following notes upon the Kuriles were collected during an excursion which I made to these islands in the summer of 1878.

Owing to a continuance of foggy weather, which I do not think would find its equal even in Newfoundland, the want of harbours, and the strong currents, although I was almost a month steaming amongst these islands, it was seldom that we could effect a landing. In consequence of this the bulk of the material embodied in the following notes was written from what I saw from the deck of our vessel. However, as I had good opportunities for seeing nearly every island in the group, and many of these from several points of view, the following notes may not be altogether without value. One advantage which was gained by viewing these islands from a distance was, that I was thereby better able to judge of the number, and the general form of the mountains they contained, and to roughly make comparisons of their relative heights, than I could have done had I been actually on the islands themselves.

In a few cases I endeavoured to estimate the heights by means of sextant observations. I also made many measurements of the slopes of the mountains which I saw; but as these were made with a small hand clinometer from the deck of a rolling ship, these measurements must only be regarded as rough approximations.

I have spoken of several of these volcanos as conical, but it must be understood that this, in many cases, only indicates a general form, the true form of the slopes being approximately logarithmic.

In the majority of cases the mountains and different portions of these islands are without names, and I have therefore had to describe them by their positions.

We finished our journey northwards at the southern extremity of Kamschatka, which is terminated with high black snow-capped peaks, looking as cold, cheerless, and uninviting as the most dreary part of Iceland.

Commencing from the north we first have *Shumushi or Pervi Island.* This is the most northern of the Kuriles, and it is separated from Kamschatka by the Kurile Straits, which are about eight miles wide. Towards the south it is separated from Paramushir by the

Little Kurile Strait, about two miles wide. As compared with the other islands in this group, Shumushi is extremely flat. Looking at it as we approached the northern entrance of the Little Kurile Strait, it presented an undulating surface. Where the convexity of these undulations came down to the shore, they terminated in low perpendicular cliffs. In other places which marked the low sweeping valleys, the land rose gently upwards and backwards as it receded inland. It was opposite to the entrance of one of these valleys at a place called Myrup where we anchored. Here there were three wooden houses which had been built by the Russians, and quite a number (perhaps a score) of half-underground dwellings. On landing we found that all these were deserted, and in many cases even difficult to find, owing to the growth of wormwood and wild grasses.

The inhabitants of the island, who call themselves Kurilsky, are twenty-three in number. They chiefly live at a place called Seleno about four miles distant. In addition to their own language, they speak Russian very fluently, and also know something of the Aino language. For the last three or four years they have lived on fish, a few blay-berries and the various animals they could shoot. I mention these people as they appear to be the only inhabitants in the Kuriles north of Iterup. By going up the bed of a small stream which flows down the Myrup valley, and by travelling along the shore, I saw several exposures which showed beds of breccia overlying beds of volcanic rock. At a distance this breccia is generally of a whitish grey colour. Looking along the shore from Myrup northwards, you apparently see beds of grey breccia overlying beds of a black volcanic rock. On close inspection, however, the black rock is seen to be also a breccia, coarse in its lower portion, where it contains fragments of rocks, gradually becoming finer higher up, and finally merging into a grey tuff. The difference in colour seems to be greatly due to a difference in weathering and the action of the sea. Here and there standing up through this breccia are bands and masses of volcanic rock. One of the former of these, which has had the breccia worn away from its sides, stands up at right angles to the shore-line like a huge wall.

Its continuance towards Paramushir is marked by outliers which, by the action of the sea-waves, have gradually been cut off from it. At right angles to its length—that is, in a direction running from side to side—it is seen to have a columnar structure, which, whilst adding to its peculiar appearance, gives you some idea of the way in which it cooled.

Up the valleys masses of a similar rock are also to be found. Upon the sloping sides of these valleys the breccia (which was friable) is thick, but it is thinner near the tops of the hills.

As we entered the straits, to see headland facing headland was very noticeable. If we imagined the curves of the volcanic ridges from Paramushir to be continued eastwards across the straits, it was clearly evident that in many cases they would make an unbroken line.

When on Shumushi, by looking across the Straits at Paramushir, it was observable that in many cases the undulations, and more especially the bluffs, of the land on one side correspond with those upon the other. These observations suggested the idea that in times not far remote these two islands have been continuous. At the time when the high volcanos of Paramushir were in full activity, they probably gave forth the materials which form the breccia. At first these materials were large and coarse, but as the intensity of the eruptions gradually decreased, the ejectamenta became finer and finer, as is indicated in the deposit of tuff overlying the coarser stones. From the absence of any appearance of stratification, I should be inclined to think that this action was a continuous one; at first violent and fierce, and finally, after the beds in Shumushi had accumulated to a thickness of a hundred feet or more, weak and feeble, puffing out fine dust and ashes, which fell and formed the tuff.

This continuous action, of which we have here evidence, I may remark, is very different to the action which has been carried on by the volcanos further south in Yezo and Niphon, where we have stratified beds of varying thickness, showing that sometimes we had a violent eruption, and next a feeble one. Sometimes these rapidly succeeded each other, but at other times, as is indicated by an intermediate layer of soil, there were periods of repose. The outbursts of the Japanese volcanos have been spasmodic; whilst the outbreaks which covered Shumushi, which apparently came from the high volcanos of Paramushir, have probably been more regular in their action. When speaking of these volcanos under the headings of the several islands in which they occur, I will give other reasons for my belief that the building up of many of the Kurile mountains has been by a continuous action rather than by a series of spasmodic efforts.

Immediately after these eruptions we must imagine the Kurile Strait to have been bridged across by the lower part of a continuous volcanic curve. Subsequently, because the materials which formed this bridge were soft, the sea has gradually eaten itself a channel through it. This channel is not like the channels between the other islands, almost unfathomable, but shallow. The greatest depth being about thirteen fathoms. Whilst this was going on, subaerial actions have worn out the ridges on the volcanos and the slight hollows on Shimshis, which now form the valleys, shallowing the sea by the material derived from the land near their entrance.

At the southern entrance to the Little Kurile Straits are a number of small islands called Torishima (Bird Islands). These I did not see.

Alaid Island.—This is a small island lying almost eleven miles off the north-west coast of Paramushir. Its general appearance is that of a solitary cone. From a rough observation made at a distance of almost six miles this appears to be over 3,000 feet in height. When I first saw it, we were steering N.N.E. between it and Paramushir. At this place we sounded with forty-five fathoms of line without finding bottom. At that time the base of Alaid was covered with clouds, but above these the top showed itself like a huge wedge-shaped cap. The edge of the wedge, which apparently was the ruined rim of an old crater, formed the top ridge of the mountain. This ridge is on the W.S.W. side. As we continued on our course, the N.E. end of this ridge rose in a point, and was seen to be the highest portion of the island. Subsequently, when I again saw this mountain, I had an uninterrupted view from its summit to the base. On the S.W. side the slope near the top was 25°. Lower down this gradually decreased to 12°. From the E.S.E. this side of the mountain was seen to have a slope of 30°, and an almost perfectly symmetrical appearance. The measurement of 25° had been taken along the edge of some degraded ridge which at the time of observation formed a profile of the mountain. On the N.E. side the slope at the top was almost 23°, and lower down 23°, and near the base 13°. From all points of view the mountain exhibited a distinct and beautiful curve. Looking at the surface, this was exhibited as a sweeping hollow. And if we except a few deep furrows which had been cut by rain and weather, its contour was perfectly regular.

Round the base of the mountain there was a growth of scrub.

In many places the shore-line was seen to be bounded by low cliffs. At the S.W. end these terminate in a small abrupt peak. These cliffs have in places a stratified appearance, a few thin earthy beds being intercalated with beds of ashes. From the way in which any one of these beds is seen to be continued along the shore-line, and also upwards along the scarp of the furrows, it would seem that the structure of the outer portions of this mountain must be that of a series of skins, or superimpose more or less conically formed envelopes. Although I looked carefully over the S.E., S., and S.W. slopes of this mountain, nowhere did I see anything which looked like or indicated the presence of a stream of lava.

From the structure exhibited by this mountain, the apparent absence of lava streams, and its beautiful form, the slopes of which, so far as the eye could judge, were of logarithmic curvature, this mountain, like many others in the Kuriles, of which I have yet to speak, was in all probability built up by a more or less continuous action, and consequently exhibited that elegant form which is natural to any heap of loose materials. Since the last eruption materials have been washed down from higher to lower levels, the top being made a little steeper, and the base more horizontal. [Alterations near the summit, tending to increase the steepness, have probably taken place more rapidly than at lower levels, from the fact that degrading agencies like rain would, for many reasons, be more active at high levels than at low ones. It is also possible that horizontality, and even a quaquaversal internal dip, may have been provoked, as Mr. Mallet has suggested, by the weight of the cone pressing down at the centre and raising up the rim]. During these processes furrows were cut which hold perennial snows, and plants which fringe the base grew up from drifted seed.

Paramushir Island.—This island may be classed among some of the largest islands in the group. It is about 60 miles in length, as measured from N.E. to S.W.; its breadth is about 14 miles. From what I saw of it on the N.E., N., and N.W. shores, it appears to be altogether a mass of mountains. The S.E. point, however, is said to be long and low. On the N. and N.E. shore facing the Little Kurile Straits, here and there, there are a few low cliffs; but for the most part the land slopes upwards from the sea to the summit of a line of irregularly-peaked mountains.

An irregular mountain, forming the northern end of this group, is giving off steam. It is covered with reddish scarps and patches of snow. As this mountain, which is remarkable as being one of the flickering embers of those internal fiery forces which raised the Kuriles, appears to be without name, either on the charts or amongst the inhabitants, I have ventured to name it Mount Ebeko. Three other high mountains may be picked out of the irregular collection which is presented at the northern end of Paramushir. These are chiefly noticeable for their conical truncated forms and curvatures. From near the entrance to the Straits they respectively bear S.S.W., S.W. by W., and W. by S.W. The N.W. side of Paramushir shows a mass of irregular mountains. With the exception of a few red and yellow patches or scarps, apparently marking the effects of fire, everything looks black.

Rising above these there are four remarkable mountains, which can be distinctly seen. Commencing from the north there is Mount Ebeko, which on this side presents the same irregular surface as it does when viewed from the Kurile Straits. It is easily to be recognized by the steam issuing from its summit.

Farther from the south we have:

No. 1.	A sharp peak	50° 25′ N. Latitude.
No. 2.	A well-defined cone ...	50° 20′ ,,
No. 3.	Fuss peak	50° 15′ ,,

No. 1. From the views which I had of this mountain, it showed nothing more than a sharp peak which rose above the neighbouring mountains.

No. 2 and No. 3. These two mountains are from their regular form to be ranked with Alaid, as being among some of the more remarkable peaks which build up the Kuriles. They appear to be the highest mountains in the island, and at the same time the most beautiful in shape. Approaching them in a south-westerly direction, they look like two slightly truncated cones.

No. 2, which from all points of view appears to be the highest, on its N.E. side looks as if it were joined on to some rugged hills, but from other points of view this appearance is seen to be illusory, and the mountain to be almost isolated. On the side which faced us it showed a brownish red patch; with this exception, all the rest of its surface was black. On the N.E. side its inclination near the summit was 30°. On the opposite side it was 22°. On this side it sweeps down towards the plain with a decreasing inclination. Before it becomes quite horizontal it rises to form the slope of No. 3 (Mount Fuss). The curving profiles of these two mountains have the appearance of a cycloid, but although I had not the means of determining their form, I conclude that, like all other volcanic slopes which I have measured, they must be approximately logarithmic.

Whilst here I compared the slopes of these two mountains by bringing their profiles into contact by means of a sextant held horizontally, and so far as I was enabled to judge by the eye, they were in all respects similar. The two sides of Mount Fuss appear to be balanced in form, each side having a slope of 28°. As we came closer, the profiles of these mountains, which had appeared to be perfectly regular, now showed a slightly ragged outline, no doubt due to the same cause which produced the furrows which could now be seen scoring their sides. Looking south, across the curve which joined these mountains, in among the mountains behind No. 2, a wall of rock was visible not unlike that of some ruined crater. From this point of view, the crater of Mount Fuss, which was slightly breached, was seen to be filled with snow.

As we sailed southwards, and looked back towards the N.N.E., No. 2 was seen first to the left of Mount Fuss, then towering above it, next immediately behind it, and finally to the right. From this point of view Fuss was seen to be very much truncated, and to have a very ragged and ruined crater-lip. Its sides, which were green, were suddenly terminated by reddish scarp-like cliffs, looking as if from time to time large masses from the face of the mountain had slipped seawards.

In addition to the mountains which I have mentioned, in the Admiralty Chart three large peaks are indicated on the S.E. coast.

On the whole, in Paramushir, if we except the isolated peaks, the mountains in the N.E. half are higher than those in the S.W. Apparently it is for this reason that there is so much more snow on the mountains at the northern end of the island than upon those in the southern half.

Shirinki Island.—This is a small island which has apparently a flat top, lying about nine miles from the S.W. point of Paramushir.

Makanrushi Island.—This island lies about 15 miles N.N.W. from Onekotan. When looked at from the east, it shows itself as a fine cone. On the N.W. side it has a dip of about 30°, and on the opposite side 28°. On the top three small points can be seen.

Onekotan Island.—This island, which is about 24 miles long, and from 5 to 10 in breadth, lies about 20 miles S.W. from Paramushir. On the south it is separated from Kharim Kotan by the Shistoi Strait, which is about eight miles broad. On the Chart it is shown as having six principal peaks, two of which are said to be dome-shaped. Looked at from near the north end, in a S.S.E. direction, three larger mountains can be distinctly seen, raising themselves above the rest.

No. 1, on the left, has a rounded top. At the base of this on the right there is a small volcanic cone.

No. 2, which is apparently the highest, terminates in a point.

No. 3 is a well-formed truncated cone. (Further to the right in a S.S.W. direction the truncated cone on Kharim Kotan and Makanrushi can be seen.)

One of these mountains had slopes of 30° and 29°.

Onekotan, as seen from a distance of about 13 miles, exhibits on the east side four large mountains, the two middle ones of which are well-formed volcanic cones.

Kharim Kotan.—This lies 8 miles to the S.W. of Onekotan. It is an island about seven miles in diameter. When looked at from the south, it exhibits a truncated cone.

Shiash Kotan.—This lies about 20 miles farther to the S.E. It is about 12 miles long and 3 broad. Near the south end there is a well-formed truncated cone, and near the centre a similarly formed cone, which is still higher, and is yet active. Round the shores there are many low cliffs.

Ekarma Island.—This island lies about 5 miles distant from Shiash Kotan. On its N.W. side it stands up as a high irregular cone.

Chirim Kotan.—This island is about 24 miles distant from Shiash Kotan, on the same side as Ekarma. It shows two tall hills, which from their shape are probably of volcanic origin.

Musir Island shows three small points or peaks. It consists of four small islets lying about ten miles from Shiash Kotan.

Matua Island.—This island, which is about 7 miles long, lies about 50 miles S.W. from Shiash Kotan. Near its S.W. side there is a lofty peak terminating in a sharp point. From the side of this peak steam can be seen issuing.

Raikoki Island.—This island lies about 5 miles N.N.E. from Matua. It has a flattish top, with one small peak.

Rashua Island lies about 19 miles S.W. from Matua. This island, when looked at from a distance of about 12 miles, is seen to be made up of several hills, but none of them exhibited a form which could be identified with a modern volcanic cone.

Ushishir Island lies about 10 miles S.W. from Rashua. It is said to be made up of two islands, each about $1\frac{1}{2}$ miles long, connected by a reef two cables long. When viewed from the north, one of its ends is seen to be terminated by a high peak.

Ketoy Island lies almost 30 miles to the S.W. from Rashua. It is mountainous, and its contour exhibits several rough peaks.

Shimushir Island.—This is separated from Ketoy by the Diane Straits, which are about 18 miles wide. It is 27 miles long and about 5 miles broad. On the Chart it is drawn as exhibiting three peaks at its N.E. end. One large peak, known as Prevost's Peak, and four smaller ones, are to be seen near the centre, and another mountain at its S.W. end. The three peaks at the northern end are all conspicuous, and from their form they are evidently of volcanic origin. The central one is estimated as having an elevation of 2,100 feet. When approached from the north, this peak is seen to overlook Broughton Harbour. This harbour, from its plan and description, would appear to be an old crater, which has been breached by the sea. Its length is about 3 miles and its breadth 1 mile. Round the sides it has an average depth of 20 fathoms, and near the centre of 50 fathoms.

It is surrounded by steep hills. The entrance is by a channel about $\frac{2}{10}$ths of a mile wide and with only a depth of from $1\frac{1}{2}$ to 2 fathoms. In consequence of this, it can only be entered by small boats.

The north-eastern coast of Shimushir, immediately outside the harbour, is bounded by steep hills which terminate in perpendicular cliffs.

The central mountain, known as Prevost's Peak, is very high, and in form is a well-shaped truncated cone.

On the north-west side of the peak, which rises at the southern end of the island, there is said to be a crater.

Broughton Island or *Makanruru.*—This island is situated about 25 miles from the N.E. end of Urup. As seen from the S.E. it looks like a huge mound. At its N.E. end there are perpendicular cliffs, and at its S.W. end it slopes towards the sea.

Rebutsiriboi or *Chirnoi Island.*—These two islands lie about 20 miles from the N.E. end of Urup. They each show a well-formed cone. When I saw them, the more northern was apparently giving off a little steam.

Urup Island.—This is separated from Shimushir by the Boussole Channel, 56 miles broad, and towards the south from Iturup by Vries Strait, which is about 13 miles wide. The island is about 58 miles long and 15 miles broad. On the Chart it is drawn as showing along its length 11 mountains. Looked at from the N.W. it shows a mass of mountains, many of which terminate along the coast in formidable cliffs. Amongst them there appear to be three which might be reckoned as volcanic cones. From one of these, which was bare and red, steam was issuing. Towards the south the land, although steep, is much lower; but at the southern extremity it runs up to form a terminal mass of irregular hills.

Along the S.E. coast from the middle of the island four volcanic cones could be counted. The central one of these, known as Atatsu-Nobori, is remarkable for its steepness, on one side having a slope of 50° and on the other of 49°. This is the steepest volcanic cone I have yet seen. The probability is that it is either solid or else it is formed of very fine materials. On this eastern side of the island there is a small harbour. To the south of this there are two peaks known respectively as Pai-wa-nobori and Kaira-nobori.

Ittrup or *Staten Island.*—This is separated from Kunashiri by the Pico or Catherine Channel, which is about 15 miles wide. This island, which is the largest in the Kurile group, is 135 miles long and about 25 miles broad. It contains several large blocks of mountains separated by intervening spaces of lower ground.

Commencing at the N.E. and going towards the S.W. I saw the following mountains, which I think might be classed as volcanic peaks.

1. Atseya-nobori and Moshisi-nayma, together with others, form a rough black group at the N.E. end of the island. From this latter mountain, which, when looked at from the south, shows a conical form, much steam is being given off.

2 and 3. These mountains form two sharp peaks which lie in juxtaposition.

4, 5, and 6 form the next irregular group of mountains. No. 4 is a truncated cone, No. 5 an irregular-shaped mountain (Rebunshiri-no-bori), from which steam is being given off, No. 6 is a rough-looking stony mountain with a dome-shaped top.

No. 7 is an irregular dome-shaped mountain slightly truncated (Atsusa-no-bori). When looked at in a westerly direction, it is seen to be a solitary double cone.

No. 8 is a truncated cone (Moshiri-no-bori). On the S.E. coast of Iturup there are many bold cliffs surmounted by wooded slopes. On Iturup there is one small harbour on the S.E. coast. And on the N.W. several small settlements. Near Cape Ikabanots there are also two peaks, the most northern of which is called Chiritsubo-no-bori.

Kunashiri Island.—This island is separated from Yezo by a channel about 8 miles wide; it is about 65 miles long and 12 miles broad. Near its northern end a conspicuous mountain rises up, which is known as Chacha-no-bori. This mountain shows two distinct cones, the upper one of these is sharp and pointed, and rises above the truncated summit of the lower one, which sweeps in a beautiful curve down to the plain beneath. This mountain is easily recognized by its superior height standing up black and sharp above all that surrounds it. The crater, forming the summit of the lower cone out of which the upper cone springs, is said to be filled with water, forming a crater lake, from which the upper cone rises like an island. For this reason the summit of the mountain is said to be inaccessible. Near the base of this mountain, which yet gives off a little steam, and contains deposits of sulphur, there are many hot springs.

Further south there are Suisaikenobori and Stara-na-bori, Lousoyama, and Shimanobori. Of these Lousoyama, which, when viewed in an E.S.E. direction, shows a truncated cone, yields sulphur, and still gives off steam.

At the extreme S.W. is Tatshinouse-nabori, which, when looked at in a N.E. direction, shows on its left side the volcanic curve. This end of the island is bounded by low greyish white cliffs.

Skotan Island or Spauberg.—This island lies about 40 miles from the S.E. coast of Kunashiri. It is nearly circular in form, having a diameter of about 5 miles. At a distance, when looking in a southerly direction, it appears to be rugged, and not to have any distinct peak, although the "China Pilot" says that from the centre there is a mountain which is even and uniform to its summit.

Itashibai Rock, Paraku Island, Shibrton Island, Mushirika Island, Hamkaru Kotan Island, Akiro Island, Sisio Island, Moyurure Island.—These are flat rock-bound islets lying to the S.W. of Skotan, and between it and Yezo. Looked at from a distance, they appear like a broad black line drawn upon the horizon. From the outliers which they throw off towards each other, and also towards the adjacent mainland, which in all respects resembles them (being flat, and with a slope of 20 or 30 feet down to the shore), it is probable that not only were these islands at one time continuous amongst themselves, but were also at the same time united to the N.E. end of Yezo.

Conclusion.—In looking at the Kurile Islands, we see that they form portions of the long chain of volcanic mountains which bound the western shores of the Pacific. If we compare them with the group of volcanic mountains which we find to the north of them in Kamtschatka, or with the group we find in Japan to the south, we shall see that they are probably of more recent date. In Japan many of the volcanos have become extinct, and since the first outbursts of volcanic rock I think that it can be very clearly shown that many stratified rocks have been deposited on their flanks. Besides these old volcanos, there are in Japan many which are comparatively recent. Looking at the more recent stratified and volcanic rocks of Kamtschatka, it is probable that there has been a sequence in events not unlike that which seems to be indicated in Japan. As to what this sequence has been, I hope to explain in another paper.

In the Kuriles, on the other hand, the volcanos are altogether recent, and, from what I saw, sedimentary rocks are as yet without existence.

In Japan many of the volcanos have suffered so much by denudation that their original forms have in many cases been destroyed. In the Kuriles, on the contrary, the greater number of the more important mountains show a well-defined form. Their sides are covered with ashes, and they show those slopes which indicate that they have suffered but little since they were first built up.

Without going into a detailed description of the differences which exist between the mountains of Japan and those of the Kuriles, it seems evident that these latter must be regarded as being much the younger. As a whole, they are probably contemporaneous with the younger volcanos of Kamtschatka and Japan. They are so to speak amongst the last of the links which together build up the volcanic chain which bounds the shores of the West Pacific.

Altogether in the Kuriles I counted about fifty-two well-defined peaks, and of these nine are certainly active. No doubt there are many more—those which I have enumerated being only the mountains which I saw. All these mountains, from their shape alone, I should say are volcanos; and farther, from their shape we see that they must be of quite recent origin.

Besides these there were many mountains of irregular forms, which might also be classed as volcanos; and in addition to all these there must have been many mountains, both regular and irregular, which I had not the opportunity of observing. Altogether, in the Kurile Islands, the area of which is reckoned at 14,865 square kilometers, there is a collection of active and recently extinct volcanos, as compared with the area on which they stand, equal to the groups we find in any other volcanic district. When we look at these mountains, we must remember that they represent so many orifices, by which material has escaped from beneath the superficial crust of the earth.

The work which has here been done in building up new land is, on the face of it, exceedingly great. If, however, we compare the volcanos of the Kurile chain with those of Kamtschatka lying to the north, or those of Japan to the south, we shall find that these volcanos of the older countries, Kamtschatka and Japan, as land formers, have done greater work, and raised up higher mounds above the level of the sea than anything we find in the Kuriles.

At first sight this would seem to indicate that the forces which are driving up material through these vents were waning in their powers, and that when mountains like Klutchewsk (16,500 feet) in Kamtschatka, or Fujiyama in Japan (12,365 feet), were raised, the volcanic energy of the West Pacific was greater than when the smaller mountains of the Kuriles, whose elevation perhaps does not exceed 6,000 feet, were uplifted. First it must be observed that I have here compared the mountains of the Kuriles with mountains whose formation was probably contemporaneous; and secondly that these latter mountains were commenced to be built up from a land surface, whilst those of the Kuriles probably were built up from the bottom of an ocean which is perhaps the deepest in the world.[1]

Looked at in this way, although the Kuriles may not have done so much as the more recent mountains of the groups lying to the north and south of them in adding to the land surface of the globe, they may represent vents from which as much material has been ejected, and this by forces just as powerful as any of more ancient date.

From the few specimens I collected, the rocks which have been erupted appear to be augitic andesites. These rocks are similar to those in Kamtschatka, Japan, Java, New Zealand, those described by Prof. Zirkel as characteristic of a large area in the 40th parallel, many in Hungary, and, in fact, they have a character in common with many volcanic rocks of recent origin, which have been collected in many parts of the world.

That we should find the same character of rock breaking out at so many points, and these in many cases along the same volcanic line, is extremely interesting.

In reading the description of the several islands, it must be observed that mention of streams of lava has been omitted. The absence of lava streams, as compared with the number you find in a country like Iceland, is very striking, and at the same time suggestive of the way in which these islands have been built up.

From the small number of mountains which are still giving off steam, as compared with those which are apparently quite extinct, it would seem that the activity of the Kurile chain is fast becoming spent. Why a volcano should become extinct is an interesting speculation. Probably it is that by giving off vapours its energy is becoming exhausted. Another suggestion would be that, by building up cones of such a height, it has gradually destroyed itself by its own increasing hydrostatic pressure. If this were the cause, we should expect to find that when the forces were no longer strong

[1] The soundings made by the *Challenger* gave for one of the depths to the east of the Kuriles 27,930 feet—the deepest sounding in the Pacific.

enough to force up the column of lava which fills the tube they have built by piling up ashes, they would find a point of weakness in its sides, and parasitic cones would be formed. When we see such parasitic cones it is not at all unlikely that they may indicate an extinction of visible volcanic energy by means of hydrostatic pressure.

Nature, however, when working geological changes of this description, works under variable conditions, and if it were possible for us to determine with certainty the reason why the various volcanos have become extinct, we should find that a complication of causes had been in operation, and in no two cases ought we to expect to find agencies which had been anything more than approximately the same.

II.—Dingle and Glengariff Grits.

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

(Read before the Royal Geol. Soc. Ireland, April 21st, 1879.)

FROM the comments on my discussion of the relations existing between the Dingle beds and the Glengariff grits, with the accompanying diagrammatic section (Geol. of Ireland, chap. iv. p. 52), it would appear that it is not as clear as it might be. I therefore propose now to explain myself more fully on this subject.

But first I would refer to the recently published memoir on "The Old Red Sandstone of Western Europe," by Dr. A. Geikie (Trans. Roy. Soc. Edinb., vol. xxviii. p. 345), as his statements in reference to the Old Red Sandstone of Scotland are more or less connected with the present question. At page 347 the author states:—1. "My own work in the centre and South of Scotland had proved the Old Red Sandstone to consist of two great divisions—a Lower passing down conformably into the Upper Silurian Shales, and an Upper graduating upwards into the Lower Carboniferous Sandstone, with a complete discordance between the two series." At page 353, when contrasting the regular uniformity of the rocks of Silurian age with those of the Old Red Sandstone, he states respecting the latter: 2. "No such general uniformity of stratification presents itself. On the contrary, with the accumulation of the deposits in limited basins come local and often peculiar features, whereby even contiguous tracts are distinguished from each other. It is still possible roughly to make out with more or less clearness the limits of these basins, etc." These remarks, as I have shown in a former paper, are very applicable to the Irish rocks;[1] as everywhere, except in South-west Ireland, the rocks similar to those called by Dr. Geikie "Upper and Lower Old Red Sandstone" are discordant; while everywhere the "Upper" graduates into the Carboniferous rocks, and in different localities the Lower passes down conformably into the Silurians. We also find great lithological

[1] Geikie still retains the name *Old Red Sandstone*; but as he has proved a complete discordance between the Upper and Lower, he has come to the same conclusion as myself, and the names by which the two groups are called does not materially signify.

differences in the rocks of both the Upper and the Lower Old Red Sandstone in the various areas or basins.

Let us now return to the Dingle and Glengariff rocks. Geikie, at page 354, divides up the rocks he classes as the *Lower Old Red Sandstone* of Britain, into five great "Basins of Deposit." No. 4 he calls the deposit of "*the Welsh Lake*" Basin, and on looking at a geological map of Great Britain and Ireland, it is evident that the rocks the subject of this paper are some of those accumulated in the north-west portion of this basin.

Although Griffith classed the Dingle and Glengariff rocks with the Silurians, while Jukes classed them as Lower Old Red Sandstone, yet both would seem to have agreed that the Dingle beds were equivalents of the older portion of the Glengariff grits;[1] or—as stated by Griffith before the Society—the visible Glengariff grits, *as a mass*, are higher up doubtless than the visible Dingle beds *as a mass*.

These observers also agreed that while the Dingle beds are capped unconformably by the "Old Red Sandstone,"[2] the Glengariff grits extend upwards conformably into the "Old Red Sandstone," and from thence up to the Coal-measures. The Dingle beds to the westward of the promontory, near Dingle, as indicated in the accompanying diagrammatic section, are at least 10,000 feet thick, but eastward higher beds occur; and it is even possible, although I believe it improbable, that nearly the whole thickness of the rocks may be under the "Old Red Sandstone" of Slieve Mish near Castlemaine. On the other hand, south of Dingle Bay the Glengariff grits, as far as seen, have been estimated to be of about a similar thickness; this being due to the upper beds occurring in that area, while the lower 3,000 or 4,000 feet, which in the Dingle Promontory rest on the Marine Silurians, here, although probably present, are not exposed to view.

It is evident that a nearly east and west fault, having a downthrow to the northward, extends along the valley of Dingle Bay, the throw near Killorglin being about 5000 feet, as here the Coal-measures are brought down nearly, if not quite, into juxtaposition with the Glengariff grits.[3] The situation, in about which this Dingle Bay fault occurs, is indicated in the diagrammatic section. In this section, other faults, minor breaks and undulations, known to occur in the country to the south, cannot be represented; the horizontal distances however are nearly correct; that is, the distances from the centre of Dingle Bay to those of Kenmare River and Bantry Bay. The distance from the south boundary of the "Old Red Sandstone" south of Dingle Bay to the north boundary of the "Old Red Sandstone" north of the Kenmare River is about sixteen miles. In the diagram-

[1] In Memoirs Geol. Survey of Ireland, Expl. Sheet 182, *f.n.* page 10, Jukes says, "an interpretation" (that of Griffith) "which is theoretically the better of the two."

[2] Here and hereafter in this paper the Upper or Carboniferous Old Red Sandstone will be spoken of as "Old Red Sandstone," while the Lower will be called "Glengariff grits" or "Dingle beds."

[3] If we consider the difference in the heights of the ground occupied by the "Old Red Sandstone" and that in which we find the Coal-measures, the latter, in depth at the fault, ought to be lying against Glengariff grits.

matic section it is shown that near Dingle there is a thickness represented by the strata *A*, *B*, *C* and *D*; these rocks or the major portion of them are also found in the country to the south, but in addition to these are found the rocks *E*; and upon the latter the "Old Red Sandstone" rests conformably.

We have now to account for the fact that while the strata *E* were accumulating in the country south of Dingle Bay, no contemporaneous beds were laid down in the western portion of the Dingle promontory. From the records of the rocks it appears that for a time after the Marine Silurians were deposited, there were successive accumulations of matter, represented by the strata *A*, *B*, *C* and *D*, on the whole of the area; but after the strata *D* were deposited a great disturbance took place north of the line of the valley of Dingle Bay, and the rocks to the north of the bay, but especially to the westward, were squeezed up, upturned, and brought under the influence of a denudant. But at the same time, while this was taking place in the northern portion of the area, in the country to the south, rocks were still being successively deposited, and the strata, represented by *E* in the diagrammatic section, accumulated. How this could take place has been fully described by Le Conte [1] and others, who have made the sinking and upheaval of land their special study; it is therefore unnecessary for me to enter into it.

But after the strata *E* in the south country were deposited, a change took place in the north country, and the result of this change was; that instead of the rocks being denuded,—on them the "Old Red Sandstone" was deposited; as well as on the rocks in the south country; while over it, in the whole area, were successive accumulations up to the Coal-measures. In support of this hypothesis, the sections published by Jukes show that the "Old Red Sandstone" in the country to the southward is thicker than to the northward; also that on the Dingle beds and the accompanying Marine Silurian it is of unequal thicknesses, while still farther northward it gradually becomes thinner.

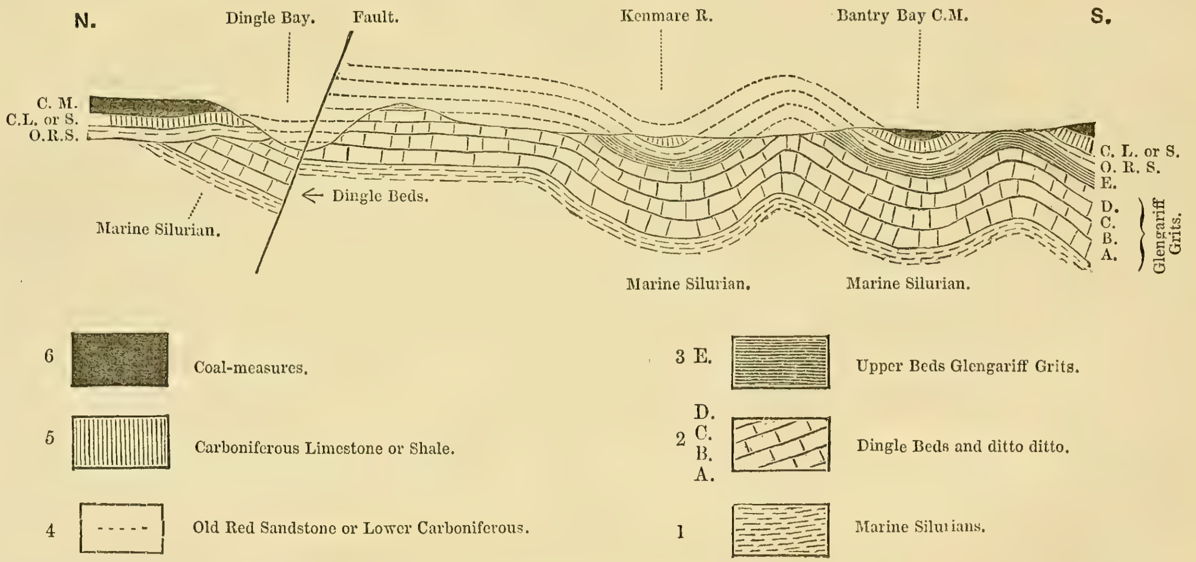
At the commencement of the paper attention was directed to Geikie's observations as to the Scotch rocks having marked lithological differences. This can be also observed in Cork and Kerry;[2] but at the same time in this area the rocks of one type nearly invariably can be traced into the rocks of other types, while certain peculiarities are more or less common to all; and one of the more marked peculiarities is the presence of metalliferous strata in the upper portion of the "Old Red Sandstone."

These metalliferous strata are best developed south of Bantry Bay, but they can be traced eastward into Waterford and Kilkenny; and to the north they are found south and north of Kenmare river, while further north traces are found in the Tralee and Kerry Head districts, and to the N.E. in the counties of Limerick, Tipperary, and Clare. In

[1] American Journal of Science and Art, ser. iii. vol. iv. pp. 345 *et seq.*

[2] To the northward, near the margin of the area of deposition, the rocks necessarily are of a more littoral character than to the southward, for the reasons explained by Prof. Geikie.

DIAGRAMMATIC SECTION SHOWING THE RELATIONS BETWEEN THE ROCKS NORTH AND SOUTH OF DINGLE BAY.*



* The dotted lines between Dingle Bay and Bantry Bay indicate the extent of the Coal Measures; Carboniferous Limestone or Shale; Old Red Sandstone or Lower Carboniferous, and Upper Beds Glengariff Grits, which have probably been removed by denudation.

the Kerry Head and Tralee districts the "Old Red Sandstone" is more or less conglomeratic; this is also the case near Douglas Head in the west portion of the strip south of Dingle Bay, while eastward thereof it gradually loses this character, and near Killarney it presents more of the usual Cork type. The Cork type, however, changes as the rocks are followed eastward, and in Waterford,[1] Tipperary, and Kilkenny, conglomerates are again found.

In S.W. Kerry and W. Cork the sequence of the rocks, as laid down by Griffith and Jukes, is as follows:—

Carboniferous Slate	(6)
Yellow Sandstone or Upper Old Red	(5) greenish, grey, and yellow grits, with shale parting containing grass-like plant-remains. (4) green, red, and liver-coloured slates.
Old Red Sandstone	(3) purplish and green grits, and slates, many of the green rocks being cupreous. (2) red and purplish grits, gritty slates, and slates.
Glengariff grits	(1)

As strata representing the groups 2, 3, 4, and 5, occur *everywhere* in this area under the Carboniferous Slate, it is perfectly impossible that in any place there can be an unconformity between the Glengariff Grits and the Carboniferous Slates. These facts in reference to the Kerry and Cork rocks have already been mentioned elsewhere; it is however necessary to draw attention to them again, on account of some misapprehension on the subject still existing.

Subsequent to the end of the Carboniferous Period, a great rupture (besides others) took place along the line of the valley of Dingle Bay, and further eastward in the Flesk and Blackwater valley, which evidently was a downthrow to the northward. However, it is readily conceivable that here, as elsewhere along great lines of disturbance, a newer displacement along the same line of weakness need not by any means have necessarily the same horizontal extent, any more than it should have the same amount of vertical throw. This Post-Carboniferous fault, which may have been on the same line as an older one, has a northward downthrow, in some places of greater magnitude than in others. Near Millstreet it seems to bring down the Coal-measures against the Glengariff grits, but eastward of this the throw is much less, while westward for some distance it also decreases; but after a time it again increases, as we proceed toward Killorglin, where it possibly may again bring down the Coal-measures against the Glengariff grits; but farther west it decreases.

I would refer to the fossils found in the Dingle beds and Glengariff grits; as statements made in reference to them are calculated to mislead. No officer of the Geological Survey of Ireland who has examined the rocks in which the fossils are found has suggested that the rocks are Coomhoola grits or Carboniferous slate. There is no doubt as to the localities in which the fossils were found. Some of them are far from being obscure.

In the Dingle beds, north of Dingle Bay, there are more or less obscure markings in various places that may be due to either land

[1] I suspect that some of the Waterford rocks, at present supposed to be "Old Red Sandstone," will eventually have to be included among the Dingle beds.

plants or fucoid remains. South of the Bay, at Valencia Lighthouse, are tracks, suggested by Mr. W. Hellier Baily to be those of a Crustacean. They may, however, be a track made by a fish, as I have seen somewhat similar tracks made by the grey gurnets on the sand floor of their tank at the Crystal Palace, Sydenham. The plants at Glanroe, west of Coomasahara, are well preserved and are perfectly distinct, and Mr. Baily's diagrams show that some of them are indistinguishable from those called *Sagenaria Veltheimiana*, found in the "Old Red Sandstone" at Tallow Bridge, co. Waterford, and at Kiltorcan, co. Kilkenny.

NOTE IN PRESS.—Since this paper was read Mr. Baily has found similar "Kiltorcan type" plants in other localities in the "Glengariff grits."

III.—NOTES ON THE SURFACE GEOLOGY OF A PART OF THE MISSISSIPPI VALLEY.

By W. J. McGEE, etc., etc.,
of Farley, Iowa.

A SOMEWHAT detailed description of the surface deposits of North-eastern Iowa, with references to observations of a similar nature in other localities, and some general conclusions, was read by the author before the American Association at its St. Louis meeting, and is printed in the Proceedings for 1878.[1] Since the preparation of that paper additional observations have been made in the same region; and some other localities, mainly in the State of Illinois, have been visited. A general section has been made across the northern portion of this State, from the Mississippi on the west to Lake Michigan on the east, at about 42° N. lat. A like section has been made the greater part of the length of the State from north to south, at about long. 89° W. from Greenwich. The data employed in the construction of these sections were chiefly derived from personal observations on the surface, in channels of erosion, and in artificial excavations; but use has also been made of the observations of other persons, collected by means of extensive inquiries from, and correspondence with, local geologists and others. In Iowa, a formation, believed to be distinct from any previously described, has been discovered, and a rather anomalous distribution of the member considered to be the equivalent of the loess has been brought to light. Several *åsar*, which seem to be homologous with those of Scandinavia, have also been traced over some distance.

Advantage has been taken of the wide circulation of the GEOLOGICAL MAGAZINE among workers in this department of geology, to lay before them a brief *résumé* of these observations, in advance of any more comprehensive publication. The division of the superficial deposits into separate formations or members, adopted in the paper just mentioned, will be adhered to, but the description of each will be so modified as to apply to the wider area since examined; and

[1] The full title of the paper is, "On the Complete Series of Superficial Formations in North-eastern Iowa, by W. J. McGee."

in other respects, only new matter will be presented, collated since the meeting of the Association.

General features.—The complete series of surface formations in this region consists of six distinct members, though it is unusual to find all in the same section. Any one or more may be absent, and the sixth, or lowest, is but seldom seen. Some of these members may be subdivided into two or more seemingly distinct portions in particular sections where a considerable thickness is exposed; but none of these subdivisions are found to remain constant over large areas. The individuality of each of the six principal members, however, is preserved over a large territory. They may be recognized, indeed, in descriptions of drift phenomena in any glaciated region. It is believed, hence, that only confusion would result from any further subdivision of the drift deposits of this part of the Mississippi Valley; and it is also believed that the grouping together of any two or more of these members will only tend to confuse the mind in regard to the agencies to which they probably owe their origin.

For reasons which cannot be fully set forth in a descriptive paper, the writer is inclined to provisionally hold that these six members were formed during three distinct epochs, probably separated by considerable intervals. It is believed, also, that all are due either directly or indirectly to glacial action, and, hence, that they afford evidence of three separate glaciers. These epochs, and their corresponding formations, are represented in the accompanying table, in their natural order. (See opposite page.)

There can be no doubt that the advantages to be derived from a systematic classification of the surface deposits are relatively as great as those resulting from the like division of the older rocks; though it must be admitted that the arbitrary divisions are not always as readily recognizable. That classification suggested by the deposits of the Mississippi Valley, and which is here offered, may not, however, be generally applicable without considerable modification—though the principal divisions have already been recognized by geologists over most of the glaciated portions of the northern hemisphere.

The recent fluviatile deposits are disregarded in this classification. It will, perhaps, be unnecessary to remind the reader that this is by no means a prominent class of formations on the Western prairies, and that their relations cannot be well studied.

Member number one.—This member is usually confined to the vicinity of the larger water-courses, and their tributaries for a few miles from their mouths. It very frequently attains a thickness of 20 or 30 feet, and sometimes much more, along the Mississippi and its larger tributaries; but it diminishes in thickness as the river is receded from. If the valley does not reach the sedimentary strata, but is wholly eroded in the drift materials, there is usually a constant diminution in the thickness of the member until the general upland level is reached, when it disappears. On the contrary, if the valley has a single broad flood plain, bounded by high hills, extending up

CLASSIFICATION OF THE GLACIAL DEPOSITS OF THE MISSISSIPPI VALLEY.

EPOCHS.	MEMBERS.	
EPOCH III.	MEMBER No. 1.	A whitish-yellow, loess-like clay, unstratified, free from gravel, sand, and boulders.
	MEMBER No. 2.	Very pebbly and gravelly clay, with sand, and small rounded and water-worn boulders.
	MEMBER No. 3.	Coarse yellowish clay, with sand, gravel, pebbles, and large angular, subangular, and rounded boulders, sometimes striated. It is sometimes imperfectly stratified, and contains lumps of blue clay.
EPOCH II.	MEMBER No. 4.	A blue clay, often fine and clean, but sometimes with sand, gravel, and boulders, many striated. It frequently contains wood and other organic substances.
	MEMBER No. 5.	Dirty-yellow or brownish clay or sand, with much gravel, pebbles, and boulders both rounded and flattened, and often striated.
EPOCH I.	MEMBER No. 6.	Deep-brown gravel or clay, with yellow streaks; cemented into a ferruginous conglomerate where sandy and pebbly.

to the general level, as is sometimes the case, this member may be found only on the brows of the hills, having been removed from their bases by erosion, and evidently never deposited on their summits.

Stratification has never been observed in this member, except where it has been re-arranged by fluviatile agencies, and mixed with sand and gravel, as it frequently is in "bottoms." It has the "vertical internal structure" described by Pumpelly, which characterizes the loess of China, and vertical cracks and fissures form in it during seasons of drought. In consequence it washes easily, especially in a vertical direction, and surfaces covered by it are characterized by great numbers of steep-sided and narrow, irregularly ramifying ravines. In this respect, as in many others, it strikingly resembles the loess of the Missouri Valley,—the "bluff-deposit" of several American geologists. Indeed, it has been traced by the writer, with no important breaks, from the Missouri, where characteristically developed, into the most north-easterly portions of Iowa; and at no place could any essential or well-defined distinction be drawn between successive sections. True, the materials are not so finely comminuted in the latter region, and there is a greater admixture of foreign substances; and in consequence of this and of its greater tenuity, it is much less compact than the true loess. Still, banks 25 feet high and sloping not more than 10° from the vertical, have stood for years with but little change along the Wapsipinnecon river, in Jones county, Iowa; and steps cut in banks nearly as steep may be used for several consecutive seasons, just as they have been seen to be by the writer in Western Iowa and in Dakota and Nebraska —*the* loess region of America, *par excellence.* The greater the thickness, too, the more striking is the resemblance to the typical loess. The calcareous concretions characteristic of the loess have not been seen in Northern Iowa and Illinois, however, nor are the tubular rootlet-like pores, lined with carbonate of lime, on which Baron von Richthofen lays so much stress, very clearly defined. It would seem, though, that this member, wherever found, is a somewhat modified but probably equivalent representative of the loess proper.

As previously intimated, however, its distribution sometimes seems altogether anomalous. In passing from north to south over the western half of Dubuque county, five or six "divides" are crossed. These seem to be quite independent of the general drainage system, as they all extend in very nearly the same direction (about S. 75° E.), and are in many places cut by the nearly transverse water-ways and valleys of erosion. Their width is very irregular, but seldom exceeds a mile or two; and they are generally much broken and cut up by ravines. Their surfaces consist of the member number one of this paper. Its depth is not great, very rarely exceeding 20 or 30 feet; and it thins out and finally disappears on approaching the lower level of the intervening areas, just as it usually does in approaching the high levels bounding valleys covered by it. These broad intervening valleys may have a width of 4 or 5 miles, and their surfaces are composed of unmodified glacial drift, with exposed boulders. There is no evidence that these areas were ever overspread by the loess-like deposit, and that this was subsequently removed by erosion—indeed, in many instances, the lines of drainage are such as to show conclusively that this could not have been the case.

The same member is often found, also, covering the summits of kames, which, like the divides, overlook the country for miles around. This has been observed not only in Iowa, but in Illinois, near Clarendon Hills, 20 miles west of Chicago, on nearly the highest land in the State, and in Macon, Christian, Shelby, and Fayette counties, near the southern point of the State, where the surface of the kames graduates directly into the true loess. This will be recurred to later.

The anomalous fact is that the loess-like member forms the upper surface of hills and ridges rising 40 or 50, or even more, feet above the general level, over which the same materials were never deposited.

Member number two.—The materials composing this member are largely coarse sand, gravel, and well-rounded and water-worn pebbles, with more or less of clay. The pebbles are both local and erratic, and very rarely, if ever, striated. The materials are frequently stratified and assorted, when the member is thick. Sometimes the overlying formation graduates into it, but usually there is a clear line of demarcation. More frequently, indeed generally, it graduates into the subjacent member. Hence its thickness is difficult to determine; but from one to five feet may be taken as the most common variations.

Though found to almost invariably accompany member number one in North-eastern Iowa, where there are large quantities of chert, which forms a prominent material in the pebbly member, it has been found absent in many localities. It can, therefore, scarcely be considered a constant feature in the superficial deposits; but its occurrence is much too general to allow of its being disregarded. It does not always present a common aspect. For instance, in Jersey county, Illinois, it consists of nearly pure sand, often accumulated in long strips or bars. Here the true loess of the Missouri covers it.

Kames and åsar are composed in a large part of this member, considerably thickened. Like member number one, it frequently exists at a higher level than any of the surrounding deposits of unmodified drift. If these two could be mingled, the mixture would contain about as much gravel and sand as, though fewer boulders than, the ordinary glacial drift. They are supposed to have had a common origin; and from their anomalous distribution the conclusion seems inevitable that they were, at least in some places, deposited before the complete disappearance of the ice of the last glacier.

Member number three.—This forms the natural surface over most of the region described. It is simply unmodified or slightly modified glacial drift, and is distinguished by the same features here as elsewhere. Its colour is yellowish to light brown, usually a dirty yellow. Its materials are sometimes imperfectly assorted and stratified, with intercalated layers and lenticular patches of gravel and sand, but are commonly wholly devoid of arrangement. Boulders of the Archæan rocks from far to the northward (few have travelled less than 200 miles, and many much more) are abundant and quite large, frequently reaching a diameter of 8, 10, or even 12 feet; and a few are striated. In the visually boundless, and almost perfectly level prairies of Central Illinois, the boulders are but rarely found on the surface, though quite as frequently encountered in excavating wells as in Iowa. Over these vast champaigns there seems to have been a greater assortment and vertical distribution of materials, in the order of their fineness, than is usually observed. Granite is the predominating material of the boulders, but quartzites and other classes of rocks are represented. Hornblendic rocks are rare in this member in North-eastern Iowa, but are frequently observed in some other localities. Lumps and bands of blue clay, easily identified with the subjacent member, are a common feature. The pebbles and gravel are made up both of northern and local rocks. In the parts of Iowa and Illinois in which the Niagara Limestone (the Mississippi Valley equivalent of the Wenlock group) crops out, there are great quantities of chert, or hornstone, both in perfect nodules and in splintered fragments, mingled with the drift.

The average thickness of this member may be roughly stated at 20 or 25 feet, though it is very variable. Its base is far from being horizontal, but is to a remarkable degree conformable with its surface; and the same may be said of the subjacent member. Before the deposit of either, the surface of the sedimentary rocks had been eroded into valleys and ravines, and a like process took place subsequent to the deposit of each; and the recent contours correspond closely with their pre-glacial prototypes.

Member number three is by far the most continuous and constant over wide areas of any of the superficial deposits. It is only interrupted by occasional ridges and *roches moutonnées* where the older rocks are exposed, and in a few valleys where removed by erosion. It does not extend as far southward as the subjacent member, however. On the meridian of 89° W. it was only traced to about lat. 39° 30′, while the blue clay extends nearly or quite a degree further. Along its southerly margin it gives place to a deposit usually spoken of as littoral or lacustral (but which is probably only a considerably modified glacial drift); and only the underlying formation is usually considered to be of northern origin. Further to the northward, where number three is well developed, it is universally recognized as glacial drift, but is seldom distinguished from the next member. The writer has traced this so-called lacustral deposit of the southern drift regions northward into the region of member number three, and found the one to graduate into the other; the relative position of the next member meanwhile remaining constant.

Member number four.—The colour of this member varies from bluish white to black; the prevailing colour, where not mentioned, being deep blue. This colour is due to the presence of black oxide of iron. In North-eastern Iowa it rarely contains boulders or pebbles, though in other localities they have been found quite abundant. Such as are found in that region are usually of the hornblendic rocks, syenite, diorite, hornblende schist, etc. Granite, which characterizes the superincumbent member, is rarely seen in it. This distinction has not been observed in other localities, and is probably only local. A much larger proportion of the boulders is striated than in member number three. The pebbles are both local and erratic, and there are sometimes intermingled fragments of ferruginous conglomerate and lumps of dark brown granular clay, easily identified with member number six. The materials are sometimes imperfectly stratified, having intercalated beds and bands of sand, gravel, or differently coloured clay, often lenticular in form. Frequently the clay is very fine and clean, affording an excellent pipe or potter's clay, and exhibiting a columnar and jointed structure when dry. Parts of it are sometimes so indurated and laminated as to resemble shale in structure and consistency; and fragments of this shale are occasionally so highly bituminous as to be imperfectly combustible. This is most frequently the case where quantities of vegetable matter are found associated. It is not very uncommon indeed for the vegetation itself to be converted into lignite. Though there is generally a thin stratum only of this member so highly bituminous, it is not very rare to find the whole mass so rich in carbon, nitrogen, etc., as to act as an excellent fertilizer.

It is very common to find wood in this member, which may be either in the shape of small fragments, or of trunks and branches of trees. These may be sound, and so slightly mineralized as to burn readily, or they may be almost wholly decomposed. The species represented are usually identical with those now found on the surface in the same region; but there is a much larger proportion of coniferous trees in the drift than growing upon the present surface. Endogenous plants of undetermined relations have also been observed, as well as cones, leaves, etc., though these are so indifferently preserved, and in so fragile a matrix, that they cannot be successfully studied. It is impossible to get good specimens into the hands of palæo-botanists. These remains are very abundant near Otterville, Jersey county, Illinois, where the structure containing them (and which is largely made up of vegetable humus, with many logs and fragments of wood and bark) rests upon the Keokuk Limestone (the third formation above the base of the Sub-Carboniferous, noted for its geodes), and is overlaid by (1) 20 feet of blue clay, with a few boulders, and (2) 20 feet of brown clay, with a little gravel and a few boulders near its base. Coniferous trees are not now found in the vicinity. Peat is also found occasionally, but is usually quite metamorphosed. Sometimes, however, its mass is well preserved, as in the case of a stratum a foot in thickness just 100 feet below the surface in Mendota, Illinois, passed through in boring a well. Many specimens of well-preserved *Sphagnum* were obtained, and several, mounted on slides, have been placed in the hands of the writer.

Bones, and rarely shells, are reported from this member. None of the latter to which any value could be attached have been examined. A cranium of *Bison latifrons*, and an abnormally developed molar belonging to some member of the Ox family, which cannot be identified, have been found in place in this formation. Two molars of *Equus complicatus*, Leidy (perhaps *E. major*, De Kay), are believed to be from this member, but both were found where the total thickness of the drift was limited, and the divisions not well marked. Charred wood has been observed in several instances.

With some reservation it may be said that these organic remains occur indiscriminately in all parts of the member. When it is *wholly* unstratified, however, they are most commonly found only at or near its surface, and occasionally extending slightly into the superimposed deposit. This is quite general beyond the southerly limit of member number three. Thus in Ohio, the "forest bed" (as it was designated by Dr. Newberry) occurs above the blue clay, and seems to be distinct from it. The colouration of the clay of this member is suspected to be due to the action of the carbonic acid set free in the decomposition of the vegetation of the ancient surface, in liberating the iron from the rocks and earths, and permitting it to combine with the oxygen of the air. Even to-day the clay is sometimes so fully charged with the gases of organic decomposition that foul smells are emitted for years into wells penetrating it; and in not a few instances the water has been rendered wholly unfit for potable or culinary uses. In several cases, indeed, it has been suspected that sickness was due to the use of water collected from this member.

Ferruginous concretions are common in this member, and thin layers of bog-ore are occasionally found. Cylindrical concretions of clay, stained and partially cemented by sesquioxide of iron, frequently occur. They exhibit a concentric structure when viewed in cross-section, and are gnarled and knotted like twigs and rootlets. They may be hollow, or may yet contain the remains of the woody substances around which they were originally formed.

Member number four is believed to be the equivalent of the *Lower Till* of the British geologists, and probably of the Canadian *Erie clay* of Sir William Logan. It is observed to the best advantage near its southern limits. Further to the northward the later glacier has sometimes removed it entirely, and often mingled its materials in inextricable confusion. Still, its distinctness from the later drift is nearly always very strongly marked. In one instance only have their positions been observed to be reversed, and this in a valley (of the Illinois River, at Aurora, Illinois), and very probably by post-glacial agencies. Where found, its thickness usually averages about half that of the whole series of surface deposits; but it is absent on rocky divides, and sometimes in valleys of erosion. In view of their extensive commingling, and sometimes reversal of position, it is scarcely deemed expedient to distinguish it from the forest bed recognized by Dr. Newberry in Ohio, and by both British and Continental geologists on the other (European) side of the Atlantic.

Member number five.—This formation is usually thin, generally ranging from one to five or six feet, but occasionally expanding to a much greater magnitude. Its principal constituents are coarse sand, gravel, pebbles and small boulders, and coarse clay; and either may predominate. The character of the pebbles is the same as in the overlying member, except that there is a larger proportion of local materials. Ground and striated pebbles are more frequently found in this than in any other member.

This member almost invariably accompanies the last, and usually rests on the older rocks. It is of considerable economic importance, as, within the frequently stratified and laminated sand and gravel composing it, an abundance of good water is usually found. It sometimes graduates into the overlying member. No well-marked distinction between the two can be observed, except that of colour—the lower having generally a dirty yellow or yellowish brown colour. If the colouration of the upper member is due to the agencies suggested, it is a little difficult to see why the process should have stopped on reaching the more pebbly and stratified clays.

Member number six.—This basal member is very unfavourably situated for observation, and is so often absent that its occurrence is the exception rather than the rule. It seldom exceeds three or four feet in thickness, and often only fills the crevices in the rocks. It is rarely stratified, but often exhibits false bedding and lamination in lines conformable with its irregular base. It usually consists of a deep brown clay, quite hard when wet, and resisting erosion very perfectly, but crumbling into minute angular fragments when dried. When a freshly exposed lump of it is broken, the surfaces are found to have a granular or crystalline appearance, like that of granite. This structure renders the lumps of it found in the blue clay easily recognizable. Though the colour of the greater part of it is due to the presence of the hydrous sesquioxide of iron, it is sometimes interspersed with specks and streaks of a light yellow colour.

It is sometimes sandy, pebbly, and gravelly, and its pebbles are both local and northern, rarely striated. When sandy or gravelly, the materials have been generally cemented into a puddingstone by means of the infiltration of ferriferous solutions and the deposit of limonite. Fragments of this conglomerate are found scattered through all the upper members. The pebbles in the conglomerate, as well as those in the clay, where not cemented, are usually stained externally, and for a little distance beneath the surface, by ferric oxides. Good exposures of this member are very rare. Considerable quantities of the conglomerate (these of very fine materials) are seen at Rockville, Iowa. With a little experience and some care this member is readily distinguishable from the superimposed deposit; and the one never graduates into the other.

Disintegrated Materials.—None of these formations should be confounded with a fundamentally distinct one, due to the secular disintegration and chemical decomposition of the sedimentary or crystalline rocks by atmospheric agencies. The importance of these processes are strongly insisted upon by Prof. Raphael Pumpelly;[1] and the occurrence of such a formation over a great part of the Level Region of Wisconsin has been pointed out by Prof. J. D. Whitney.[2] Accumulations of this character, often 20 or 30 feet thick, are well known to the writer as occurring over the Niagara Limestone along the western border of the Wisconsin "driftless region." They are distinguished by great numbers of nodules of chert, often fractured by internal expansion, in the positions in which they were formed in the rock, by the presence of siliceous fossils, mainly corals and crinoid stems, with a few bivalves, and by the absence of erratics. Two miles north of Farley, Iowa, such a bed reaches a thickness of 25 feet, and is overlain by true glacial drift. It bears no evidence of having been disturbed since the decomposition of the rock.[3]

[1] In a paper read before the National Academy of Science, April 10th, 1878. See also Am. Journ. Sci., iii., vol. xvii., Feb. 1879, p. 135, *et seq.*

[2] "Geology of Wisconsin," 1853, vol. i. p. 121.

[3] This is important as bearing on the question whether a Continental glacier removes all of the lighter materials, and lays bare the rocks over which it passes.

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

IV.—Notes on some Ligurian and Tuscan Serpentines.

By Professor T. G. Bonney, M.A., F.R.S., etc.

NOTWITHSTANDING the distinct assertion by more than one geologist[1] of the intrusive character of the serpentines of these districts, some uncertainty seems to exist on this point and still more as to the original character of the rock. Hence the result of my examination of a few localities, and of my subsequent studies of the rocks then obtained, may be of sufficient interest to justify publication.

I commence with the serpentine on the sea-shore to the west of Genoa. Quitting that town by the road to Pegli, serpentine first occurs a little west of Conegliano, where a small boss forms a headland by the sea. The rock is of a dull greenish colour, and is so greatly decomposed as to be worthless for microscopic examination. Still, the general aspect, form, jointing, etc., are quite those of the Lizard serpentine. I have little doubt that the mass is intrusive, though buildings, etc., prevented me from finding an actual junction with the neighbouring sedimentary rock. This can be seen within a yard of the serpentine. It is an indurated shale of schistose aspect, much shattered, and traversed by calcareous veins, looking in short as if it had been affected by the intrusion of an igneous rock. Beyond Pegli, serpentine is again found on the sea-shore. Here (just after passing some houses) is a considerable exposure of serpentinous breccia, which can be studied in the cliff and in some small skerries. This at first sight closely resembles an agglomerate, being composed of fragments of serpentine, with some of gabbro, and a few of a dark slaty rock in an ashy-looking paste, reminding me by its aspect of one of the "necks" so common on the Fifeshire coast. As I have long been anxious to ascertain whether serpentine ever occurs as a truly eruptive rock,—*i.e.* as an altered lava flow, tuff or agglomerate,—I examined this section with great care, but was unable in the field to come to a positive conclusion. The gabbro is probably the latest rock, being intrusive in the breccia, and, as I think, in the serpentine also, though the latter point was not quite so clear to me as the former.

The next two headlands to the west mainly consist of gabbro. This rock varies from a fine-grained variety of a dark greenish to bluish colour—at a short distance hard to distinguish from the serpentine—to a coarse variety composed of a white saussuritic mineral and a dark green or almost black diallage or augite. The latter rock much resembles some of the gabbros on the Cornish coast, except that the pyroxenic mineral is less metallic and the "saussurite" less abundant. It includes one or two fragments of a slaty rock of rather serpentinous aspect. I have examined a slide of the more compact gabbro. At a glance it is seen to have been highly altered. The ground-mass consists of a rather confused mixture of a clear and sometimes granular mineral, and a pale, rather fibrous

[1] D'Achiardi, vol. ii. p. 180. Stoppani, Corso di Geologia, iii. § 701. Jervis, Quart. Journ. Geol. Soc. vol. xvi. p. 480.

mineral, which is probably a variety of hornblende. In these are several rather large grains of decomposed ilmenite, some grains resembling a decomposed diallage, and a considerable quantity of a hornblendic mineral, showing here and there distinctly the cleavage of hornblende; in other parts in rather fibrous or filmy patches, many of which show a peculiar deep blue colour. On testing the last for dichroism, we observe them change from this colour to a pale yellowish olive, and find that with ordinary transmitted light the latter tint is seen in sections cut approximately parallel to a basal plane, while the blue colour appears to belong to most sections cut at right angles to it. This mineral appears, from its association and mode of occurrence, to be of secondary formation, as the hornblendic constituent usually is in a gabbro. There can be little doubt it is glaucophane.[1] A grain or two of epidote, and various minute decomposition products, are present. Though no felspar is now to be distinguished, I think the general habit and structure of the rock justifies us in assuming that this mineral was formerly present, and we may accordingly call it a glaucophane-gabbro.

As regards the brecciated rock mentioned above, the impossibility of obtaining a thin slice makes it difficult to arrive at a conclusion. The grains are not markedly angular or scoriaceous in aspect. Ilmenite, glaucophane, and a pyroxenic mineral can be recognized, with possibly bits of serpentine and of a hornblendic or chloritic rock. There is nothing about it specially suggestive of a volcanic origin; and if it be an agglomerate, I feel certain it is connected with the focus of the gabbro, not of the serpentine.

The included slaty rock gives indications of fragmental origin, but has been much altered, recalling a little some of the ashy rocks of the North Wales Lower Silurian. At present, however, it is chiefly composed of fibrous hornblendic minerals, among which is glaucophane, and granular earthy minerals, ferrite, etc. A grain of decomposed diallage (?), associated with glaucophane, is present.

Beyond this place we find on the shore of the Bay, near Pra, a bold eminence (crowned by an old fort) rising above the sands, and now isolated by a railway cutting. It is composed of a brecciated serpentine; the fragments, angular and varying from less than an inch to a foot in diameter, are cemented by a whitish mineral, which appears to be sometimes steatite, sometimes calcite or aragonite; the whole mass is in a very decomposed condition, but it appeared to me certain that it had been brecciated *in situ.*

To the west of this spot the shore becomes for a while flat and sandy. The serpentine obviously extends inland for a considerable distance, but as all that was visible appeared to be much decomposed, and there were no signs of quarries, I did not quit the coast. Even

[1] An aluminous variety of hornblende; it has been found at Zermatt (see Dana, Text-Book of Mineralogy, p. 277), and at Syra (Zeitsch. deutsch. geol. Ges. Bd. xxviii. heft 2, p. 248). For the above determination, and the opportunity of comparing specimens, I have to thank Mr. T. Davies, F.G.S., of the British Museum, to whom, as not seldom before, I had recourse when in perplexity as to the name of the mineral.

here I was not able to obtain any good specimens from rocks *in situ.* The shore, however, especially about Pegli, is strewn with small boulders and pebbles of dark green serpentine, which have probably been brought from inland by the Varenna torrent.

I observed two varieties: one a very dark green, nearly black, rock, with numerous crystals of bronzite, very like the black serpentine of Cadgwith; the other rather harder and almost free from included crystals. The latter did not seem likely to offer anything of interest for the microscope, and I already possessed a slide cut from a rock closely corresponding with the other; so that, as these specimens are not *in situ,* I have not investigated them microscopically; indeed, I feel justified, from their general identity in appearance with the serpentines of Cadgwith[1] and Colmonell,[2] in claiming for them a similar origin, without further examination.

The railway from Genoa to Spezzia traverses a large mass of serpentine, which forms the coast-line for several miles. It is first seen at Framura, and extends as far as Bonasola, being much decomposed, and exhibiting in places a curious subspheroidal structure. In colour it is sometimes a dull rusty red, sometimes greenish. Just south of the latter place occurs a considerable mass of coarse gabbro, composed evidently of "saussurite" and a greenish pyroxenic constituent. Serpentine is exposed along the coast, and obviously extends far inland up to Levanto and on to Monterosso. Just north of that village it comes to an end; and on emerging from a tunnel we find at the station a dark coloured rock, which is now rather schistose looking, and greatly crumpled and crushed, but appears to have been originally a shale with irregular stony bands or concretions.

After crossing this section in the train I returned to Levanto (where I had observed quarries), in order to examine the serpentine more closely. From this place the serpentine extends a considerable distance inland. Just north of the village are numerous small pits, and excellent specimens of the rock may be obtained. There are two varieties: one, the commoner, a purplish or brownish black rock, veined occasionally with dull green, and with crystalline folia of glittering bronzite—very similar to the rock already described; the other, of a more granular texture and rougher fracture, also distinctly "tougher" under the hammer, rather greener in colour, with a less metallic lustre on the included mineral. South of the village is also serpentine. The first rock which is exposed on the shore is a breccia (the fragments resembling the former of the above serpentines and just beyond it is a great dyke (not less than seven yards wide) of very coarse gabbro. The gabbro is rather decomposed and consists of "saussurite" and diallage—the former decidedly predominating, and the crystals of the latter often 1 inch and sometimes 2 inches in diameter. Beyond this is more serpentine.

Magnificent quarried blocks of beautiful brecciated serpentine were lying near the railway awaiting shipment. On inquiry, I found the quarries were some four or five miles distant among the

[1] Quart. Journ. Geol. Soc. vol. xxxiii. p. 890.
[2] Quart. Journ. Geol. Soc. vol. xxxiv. p. 770.

mountains; so I procured a guide, and set off to visit them. The road passed above the quarries already mentioned, and wound round the upper part of the headland north of Levanto, till it turned up the ravine which descends on Bonasola. The country is for the most part wild and uncultivated—a waste of serpentine crags and boulders, thinly overgrown by brushwood, myrtles, and scattered pines. The serpentine is often very rotten, but masses also occur where the rock is well preserved. In general character it resembles the Lizard serpentine; joints are frequent and irregular, but sharp, often coated with white steatite; the outer surface turns brown in weathering, and often becomes rough. In one place the weathered rock exhibited a fairly perfect spheroidal structure, which, so far as my experience goes, is not common in serpentine. About a mile below the first quarry I noted a mass of altered sedimentary rock, six or seven yards long, apparently included in the serpentine. It is of a claret-red colour, is rather harder than calcite, and is evidently an indurated argillaceous rock. A coarse gabbro of the usual character occurs some distance further on. Apparently it is intrusive in the serpentine, but both are so rotten that it is not easy to ascertain their relations.

The first quarry is high up in the mountains, probably not less than 800 feet above the sea, and the surrounding summits rise some hundreds of feet higher, all being serpentine. This quarry affords a good opportunity of examining the breccia, as it is some forty yards long and perhaps twelve deep. The beautiful structure and colour is easily brought out by dashing a little water on the surface. There is another quarry about ten minutes' walk higher up, in which a similar rock occurs, and there are two or three more in the vicinity, so that there must be a considerable tract of this breccia. The result of my examinations, both in the quarry and of the great blocks at Levanto (which were hardly less instructive), may be thus summed up). The serpentine is of the ordinary type, but a red variety is as common, or perhaps commoner than the dark green. The cementing material is crystalline calcite. The rock is evidently not an agglomerate, but has been brecciated *in situ.* For example, one block might be quarried which would be a mass of serpentine, only traversed by a few cracks which had been filled up by infiltrated calcite. Another would show fragments smaller, and sometimes displaced a little, the calcite being more abundant, and the spaces occupied by it larger. Another would give no clue to its origin, but would be simply a breccia of fragments of serpentine cemented by calcite, which would now and then seem to form almost half the rock. Parts exhibit an intimate mixture of pulverized serpentine and calcite, and here and there are filmy patches of a serpentinous mineral. Yet every gradation, from the almost unbroken rock to this complete "smash," may be traced. One face of rock in the lower quarry exhibited it perfectly in a space of about four yards.

I have examined microscopically slides cut respectively from a specimen greatly brecciated and from one merely veined with calcite.

They fully confirm the opinions expressed above, and from the appearance I should conjecture the brecciation took place when the rock had become a serpentine. In one there is part of a vein (?) containing a pale feebly dichroic variety of hornblende and an associated mineral more like an altered enstatite; probably they are of secondary origin. With the calcite a little dolomite, I believe, is intercrystallized.

We have then here a mass of ordinary serpentine which has been crushed into a breccia *in situ* and consolidated again by infiltration of calcite. Any one who has examined serpentine much in the field will remember that its sharp irregular jointing and brittle nature would cause it to crush more readily perhaps than most other rocks. The whole of the hilly district bordering the Riveria di Levante has been greatly disturbed, and its rocks are often much contorted. During one of these disturbances no doubt the crushing took place. At that time limestones, which still predominate among the sedimentary rocks around this serpentine *massif*, doubtless extended above it, and the water which percolated downwards from them while they were undergoing denudation deposited the $CaCO_3$ with which it was charged in the fissures of the subjacent rock. This has now been exposed to view, all trace of the once overlying rock having disappeared.[1]

Besides the above breccia, I have examined microscopically the two varieties of serpentine, described above, from Levanto. The slide from the more granular rock (with crossing Nicols) is seen to consist chiefly of very characteristic olivine grains, separated by threads (of variable thickness) of serpentine, about equal quantities of the two minerals being present. There are the usual clots of opacite. In short, the appearance of the ground-mass of the slide is so similar to what I have already described in a Cornish serpentine,[2] that repetition is needless. Enstatite and augite are both present, as I have proved by optical tests, etc., and perhaps also a little diallage. I think the first mineral rather predominates, but there are difficulties in determining the crystalline system of some of the grains. Endomorphs of opacite are rather commoner than is usual in the enstatite. There is a little picotite. The other and compact variety exhibits a more complete conversion into serpentine. No olivine remains to show chromatic polarization, though here and there a grain is still doubly refracting. In this also there is (as might be expected) more opacite. It often forms continuous strings, is more or less present in the grains (formerly olivine), being either disseminated throughout them, or in bands towards the exterior. Diallage and enstatite are both present, the latter being surrounded by a border of a serpentinous mineral, into which the planes of principal cleavage are continued, and are often picked out by thin lines of opacite. The cleavages

[1] I should perhaps state that there is nothing to favour the idea of this crushing having been sudden, or associated with any exceptional amount of heat. It may have been the result of long-continued pressure and yielding now here now there—possibly, indeed, the process of crushing and cementation may have been repeated more than once.

[2] Quart. Journ. Geol. Soc. vol. x. sec. xxxiii. p. 916.

parallel to ∞ P are indicated by thin lines of serpentine. The same change is common in other serpentine rocks which I have examined. This second mineral can be seen with a hand-lens, forming a talc-like border to the unaltered crystal; probably it is nearly allied to that mineral. One small grain of picotite is present, and some of the most minute opacite is dichroic, and is probably manganese. Through the kindness of Prof. Liveing a specimen of this second rock has been examined for me at the Cambridge University Laboratory by Mr. C. T. Heycock, of King's College, to whom I return my best thanks. Together with his analysis I reprint for comparison those of serpentines very similar in appearance from Ayrshire and Cornwall.

	Levanto. S. G. 2·705.	Balhamie.[1]	Cadgwith.[2] S. G. 2·587.
H_2O	11·61 (H_2O + Fe.S)	14·08	12·35
Fe.S		trace	0·41
SiO_2	40·47	38·29	38·50
Al_2O_3	4·35	3·95	1·02
Fe_2O_3	7·61 (Fe_2O_3 + FeO)	2·53	4·66
FeO		4·04	3·31
CaO	0·84	0·57	1·97
MgO	34·59	35·55	36·40
MnO	0 15	trace	.....
NiO	0·49	0·15	0·59
Residue	.....	.....	1·37
	100·11	99·16	100·58

All dried at 100° Cent. In the Levanto specimen there was the slightest trace of CO_2. Hydrochloric acid dissolved 95·54 per cent. of the mass, leaving 4 46 residue as a slightly green amorphous powder. The per-centage of alumina here, as in the Ayrshire specimen, is larger than I should have anticipated, as I cannot see a trace of felspar. Part of it, however, may be due to the pyroxenic constituents, and the rest to picotite. The constant presence of nickel is interesting.

My next visit was to the quarries from which is obtained the celebrated Verdi di Prato, for centuries one of the most important decorative stones in the valley of the Lower Arno. These are at Figline, a little village between two and three miles from Prato, a town between Florence and Pistoia. Here also the serpentine, as may be seen from the railway, occupies a considerable tract of hilly country, and rises from beneath the calcareous strata which are so common in this part of the Apennines. Figline lies on the last slopes of the hills, and on approaching it from Prato the serpentine (which has the usual dusty purplish-brown or greenish-brown colour and characteristic weathering) is seen forming the right bank of the valley; while on the left bank is exposed an indurated argillaceous rock, disturbed and sharply jointed, its aspect suggesting, as does the contour of the serpentine mass itself, that the latter rock is intrusive. The quarries, which are rather numerous, are situated on the hill-side behind Figline. Almost directly on quitting the village at the lower end, we come upon coarse gabbro, of the usual character, but very rotten, and after ascending perhaps a hundred

[1] Quart. Journ. Geol. Soc. vol. xxxiv. p. 771.
[2] Quart. Journ. Geol. Soc. vol. xxxiii. p. 925.

feet, reach quarries in this rock, some of considerable size. The gabbro is coarsely crystalline, consisting of plagioclase felspar (resembling labradorite), partly of a dull bluish colour, partly changed into white "saussurite" and greenish diallage, with a rather silvery lustre, the crystals commonly varying from $\frac{1}{2}''$ to $\frac{3}{4}''$ diameter, and some dull green spots possibly denoting altered olivine. The slide, however, which I have had prepared, does not show any of the last, but consists of plagioclase felspar more or less altered, diallage, ordinary augite, and a little secondary hornblende.[1] The rock is locally known as *pietra di macchina,* and is quarried for mill-stones. It varies a little in the relative amount of diallage and felspar and evenness of crystallization, but is, on the whole, very uniform in character. I had not time to trace out its limits, but the size of the mass must be considerable.

Bearing away to the right and slightly ascending, we approached the serpentine, which forms hereabouts the upper part of the hill. The actual junction of the two rocks is obscured by vegetation, soil, and detritus, but in a water-course I obtained a fair section, which satisfied me that the gabbro was intrusive in the serpentine. Quarries in the latter rock are still more numerous than in the former, so that, though all the natural surfaces are much decomposed, there is no difficulty in obtaining a good supply of specimens.

The general character of the serpentine appeared to be very uniform—a ground-mass of a dull purple with a tinge of green irregularly mottled by the latter colour; in this are scattered rather small crystals of a greenish mineral resembling enstatite. Thin veins of green steatite are not unfrequent. After long exposure the rock becomes of a pale grey green. It is sharply but irregularly jointed, the joints often coated with a film of white steatite, and sometimes becoming brown by exposure. In general character the rock is identical with those already described and with that of the Lizard, so that, from examination in the field alone, one might fairly claim for them a similar origin. A microscopic slide shows no unchanged olivine, but in parts, as in the last described, a structure is visible indicating that this serpentine also is an altered olivine rock. I do not find any unaltered enstatite or augite, but several grains resembling the talcose mineral described above. In another slide, cut some years since from a specimen purchased in Florence, the enstatite still shows faint tints and a little of the serpentine in the 'strings' exhibits slight chromatic polarization.

On returning from the quarries I descended into the glen above Figline, and a short distance from the latter found stratified rock by the road-side. This at first was an argillaceous rock, with concretions, looking as if it had been much crushed. A little nearer occurs a harder, bedded rock, bands of which have a flinty texture and fracture of a dull reddish colour.[2] The peculiar sharp jointing, baked

[1] An analysis of the diallage is given by D'Achiardi, vol. ii. p. 84, and of the felspar (labradorite), *id.* p. 104. The rock is commonly called "granitone" by Italian geologists.

[2] I believe this is the "gabbro rosso" of some authors.

aspect, and wavy outline of the surface of the strata, which dip at some 15° away from the serpentine, are almost enough to prove the latter intrusive. But by ascending the bed of a streamlet, and climbing up a little to the right, more conclusive evidence may be obtained. Here we have the section roughly sketched in the annexed diagram. A talus, *D*, it is true, masks the actual junction of the serpentine and the stratified rock; but the state of the rock in the little cliff is almost enough to prove intrusion. However, on looking carefully about, I found a complete proof. At *A*, about four yards from *B*, the last exposure of the serpentine, and six yards from the base of the cliff (measured on the slope), and on a lower level by a few feet, was a small slab of the stratified rock yet adhering to the serpentine. This collocation places the intrusive character of the latter beyond all doubt.

Relations of Serpentine and Sedimentary Rocks, near Figline.

A Altered stratified rock. B Serpentine.
C Stratified rock *in situ*. D Talus.

Microscopic examination of a specimen from the upper part of *D* has produced interesting results. It consists of a very fine muddy or silty ground-mass, in most parts stained of a deep red, crowded with minute organisms, some resembling Sponge spicules, often triradiate; others resembling Polycystinæ or Foraminifera, such as *Orbulina* or *Lagena*. They appear to be siliceous, and the internal parts exhibit the black cross of aggregate polarization. Two or three are pretty certainly minute Gasteropods. To determine the position of the rest is not easy. One eminent student of Microzoa, to whom I submitted the slide, claims the majority for Polyzoa, another for Polycystinæ and Sponge spicules. If I may presume, without having made such organisms a special study, to express an opinion, it would be that while some certainly much resemble Polyzoa, others are singularly like Polycystinæ. That all appear to be siliceous is not conclusive, because under the circumstances replacement may have taken place. Thus we are unable from these remains to fix the precise geologic age of the rock, but still may fairly class it with the strata of the immediate vicinity, which are, I believe, Upper Cretaceous.

In the Mineralogical Museum at Florence, Professor Grattarolo (to whom I am much indebted for information on localities, etc.), showed me a collection of serpentine and gabbro from Impruneta, a few miles from the city. These had the same general character as the above; but both rocks were much decomposed, so that, on hearing there were no excavations, I did not think it worth while visiting the locality, as I probably should not have been able to learn more than I could from the specimens.

These serpentines, then, and no doubt several other isolated patches in the Ligurian Apennines, which I had not the opportunity of visiting, must be added to the rapidly increasing group of altered olivine rocks, primarily of igneous origin. To these also belong, as I have already pointed out, the serpentines of Elba, and in our own country those of the Lizard, Ayrshire, Portsoy, with other parts of Scotland; and—as I shall show on a future occasion—of North Wales. To these also must be added some of the Alpine serpentines. Here, however, careful discrimination will be needed, for though no doubt true serpentine is present in the Alps, some of the rocks commonly mapped under that name have received it improperly, being only serpentinous, *i.e.* rocks into whose composition other minerals enter very largely, and in many cases simply serpentinous schists.

Further, it is impossible to avoid being struck with the frequent association of serpentine and gabbro; at these four localities in Italy, the two extremes being a good hundred and twenty miles apart (and I believe in several others), at the Lizard in Cornwall, and on the coast of Ayrshire—to speak only of those which I have myself visited, we have gabbro intrusive in serpentine. This can hardly be a mere coincidence. These gabbros also are remarkably like one another in aspect. Some observers, indeed, have asserted that the serpentine is the result of transmutation of a gabbro. Now that the microscope is used in petrology, I do not think we shall hear much more of that statement, which in many cases was founded only on very hasty examination in the field, and has seldom a better base than the fact that serpentine is one of those minerals which, like some people, can make a great show with but little means. It is often instructive to see how "serpentinous" a rock will appear to the eye, which, on careful examination, proves to be mainly composed of other minerals. Reflection, too, should have suggested to petrologists that felspar is not an easy mineral to remove from a rock. The case of greissen, tourmaline-rock, etc., may, I am aware, be quoted; but these are always comparatively local, while in the case of serpentine we should have to pseudomorphose masses of gabbro containing billions and billions of cubic yards so perfectly that no trace of the felspar remained, and by so strange an agent that its action is found to have stopped abruptly. The representatives, then, of altered olivine-gabbros, will be found in the troktolite group; and where gabbro and pure serpentine (*i.e.* a rock the ground-mass of which consists almost entirely of hydrous silicate of magnesia with some oxides of iron) are associated, the two rocks are of independent origin. It will be well for travellers to observe carefully the relations of these two rocks, noting especially whether, as in the above instances, the gabbro is the newer rock.

Another point of interest in connexion with these serpentines and gabbros is that they are, beyond doubt, of late Cretaceous or early Tertiary age,[1] and yet are practically identical with serpentines and gabbros which are almost as certainly of Palæozoic age.

NOTICES OF MEMOIRS.

I.—A New Jurassic Mammal. By Professor O. C. Marsh.

(From the American Journal of Science and Arts, vol. xviii. July, 1879.)

During a recent visit to the Rocky Mountains the writer spent some time in examining the deposits known as the Atlantosaurus beds, and was rewarded by the discovery of several interesting fossils, among them the lower jaw of a small mammal. This specimen indicates a diminutive marsupial, quite distinct from the one previously described by the writer from the same horizon (*Dryolestes priscus*),[2] which has hitherto been the only mammal known from the Jurassic of this country.

The present specimen, which is from the left side, has the larger part of the ramus preserved, with a number of perfect teeth in position. Most of the symphysial portion is lost, and the posterior part is missing, or only faintly indicated. The jaw was remarkably long and slender. The horizontal portion is of nearly equal depth throughout, and the lower margin nearly straight. The form of the coronoid process, condyle, and angle of the jaw cannot be determined from this specimen. The remarkable feature in this jaw is the series of premolar and molar teeth. These were very numerous, apparently as many as twelve in all, and possibly more. The premolars had their crowns more or less compressed, and recurved, and some of them were supported by two fangs. These had a small posterior tubercle at the base of the crown, but none in front. The molar teeth were all single-fanged, with elevated conical crowns. Those preserved have a distinct cingulum. The molars increase in size from the first to the fifth. All the teeth preserved have the crowns raised considerably above the upper margin of the jaw, and thus appear to be loosely inserted. A large pointed tooth lying near the jaw appears to be a canine. The principal dimensions of this specimen are as follows:

Length of portion of jaw preserved	11·5 mm.
Extent of five molar teeth	4·
Extent of entire molar series	5·
Height of fifth true molar above jaw	2·
Depth of jaw below fifth molar	1·75
Depth of jaw below last premolar	1·5
Depth of jaw below first premolar	1·4

In comparing this interesting fossil with the forms already known, it is at once evident that it differs widely from any living type. Its

[1] Jervis, Quart. Journ. Geol. Soc. vol. xvi. p. 480, states that the "diallagic serpentine" pierces the Upper Cretaceous but not the Tertiary rocks. Stoppani, Corso di Geologia, vol. iii. § 704, places it, if I rightly understand, at about the same period. Both speak of a compact serpentine "without diallage," of Miocene age. This I have not seen. See also D'Achiardi, vol. ii. p. 181.

[2] Silliman's Journal, vol. xv. p. 459, June, 1878.

nearest affinities are clearly with the genus *Stylòdon* of Owen, from the Purbeck beds of England,[1] and in many respects the correspondence is close. This specimen clearly indicates a new genus, which may be called *Stylacodon*, and the species represented, *Stylacodon gracilis*. With the genus *Stylodon*, this form evidently constitutes a distinct family, which may appropriately be termed the *Stylodontidæ*. The present specimen indicates an animal somewhat smaller than a weasel, and probably insectivorous in habit.

II.—On the Fossil and Recent Sequoiæ. By Prof. Oswald Heer. (Proceed. Inper. Geol. Instit. Vienna, March 4, 1879.)

TWO species of *Sequoia* have survived to the present time, namely, 1. *Sequoia sempervirens*, Endl. (*Taxodium sempervirens*, Lamb.), still frequent, with distichous, divaricated leaves, small globular fruit, and similar in habit to *Taxus baccata*: 2. *Sequoia gigantea*, Endl. (*Wellingtonia gigantea*, Lindley), only in isolated groups, with narrow leaves, adpressed to the branches, with much larger oviform fruit, and showing the habit of *Cupressus*. Each of these species represents a distinct type.

The Tertiary species are very numerous. *Sequoia brevifolia*, Heer, is analogous to *S. sempervirens*, as *S.* (*Araucarites*) *Sternbergi*, Goepp., is to *S. gigantea*. The Miocene species—*S. Langsdorfii* (Brongn.), *S. brevifolia*, H., *S. disticha*, H., *S. Nordenskiœldi*, H., *S. longifolia*, Lesq., *S. angustifolia*, Lesq., and *S. acuminata*, Lesq., are closely related to each other. The interval between the two extreme forms, *S. Langsdorfii* and *S. Sternbergi*, is filled up by six species—*S. Couttsiæ*, H., *S. affinis*, Lesq., *S. imbricata*, H., *S. Sibirica*, H., *S. Heeri*, Lesq., and *S. biformis*, Lesq.

Of the ten Cretaceous species, three are of the Upper, two of the Middle, and five of the Lower Cretaceous series. These last have representatives in the two living forms: *S. Smittiana*, H., in *S. sempervirens*, and *S. Reichenbachi* (Gein.), (*Geinitzia cretacea*) in *S. gigantea*. The intermediate species are *S. subulata*, H., *S. rigida*, H., *S. gracilis*, H., *S. fastigiata*, and *S. Gardneriana*, Carr.; the last three have adpressed leaves.

The Jurassic strata, rich as they are in Coniferous plants, offer no traces of *Sequoia*, which appears first in the Urgonian beds,—and then in the two extreme forms which have alone survived beyond the Tertiary Period.

Prof. O. Heer also remarks, with regard to the *Arctic Tertiary flora*, that Mr. J. Starkie Gardner's statement—that two fossil floræ very similar one to the other, but situated under widely distant latitudes, should not be considered to be coëval—is not consistent with the facts—that living plants (especially trees) are met with from the Italian frontier up to 70° N. Lat.,—that the existing flora of Grinell Land numbers among its 59 phanerogams 45 European and 6 Italian species,—and that of the 559 phanerogamous species of the Island of Saghalin, no less than 188 are found among the flora of Switzerland. The Tertiary flora of the Arctic zone cannot be Eocene, as supposed by Mr. Gardner, for in Northern Bohemia the Cretaceous strata are

[1] Geol. Mag. Vol. III. p. 199, 1866, and Pal. Soc. vol. xxiv. p. 45, 1871.

succeeded by the Brown-coal series, the oldest horizon of which is decidedly Middle Oligocene; and the Eocenes, strictly so called, are wanting there. The whole discussion, adds Prof. Heer, proves the necessity of ascertaining with more precision the age and geological position of the Tertiary floræ in each locality. At all events, the present exact knowledge of the North-Polar Tertiary floræ, he says, has been highly profitable to Geology in proving the needlessness of the hypothesis of a formerly existing "Atlantis." T. R. J.

REVIEWS.

I. — NOTES ON CRYSTALLOGRAPHY AND CRYSTALLO-PHYSICS. By JOHN MILNE, F.G.S. (Professor of Geology and Mineralogy in the Imperial College of Engineering, Yedo, Japan.) 8vo. pp. 80; 25 Woodcuts. (London: Trübner & Co., 1879.)

THE study of Geology is a wide one, implying a foreknowledge of Biology, Chemistry, Physics, and Mineralogy, and to be well acquainted with all these is rarely the lot of one man; therefore, when a geologist writes a book on Crystallography and Crystallo-physics, it is apparent that there must be a considerable want felt by geologists for a work of this kind, viz. one which, while deserting the awkward system of Naumann still taught in preference to any other by several of our teachers of mineralogy, and using the elegant system of Neumann and Miller, yet attempts (to use Mr. Milne's own words) "to give the general principles which crystallographical calculations involve for the use of those students who wish to know them, rather than for those who wish actually to employ them"

It is to be regretted (for the sake of the author) that the publication of Mr. Milne's Crystallography was delayed, owing to his absence from England, as, when the lithographed notes of these lectures delivered in Japan were sent to England for publication "in the GEOLOGICAL MAGAZINE, or elsewhere," Mr. Gurney's little book on Crystallography had not yet appeared. Had they been printed in this country earlier, they would have taken precedence in publication of Mr. Gurney's pamphlet, as they undoubtedly do in date of issue in Japan.

The author expresses himself indebted for information to Prof. Miller's Treatise on Crystallography, and Prof. Maskelyne's Lecture-notes on the Morphology of Crystals; he might also have cited Prof. Miller's Tract on Crystallography, which, though shorter, is preferable to his Treatise, at least from a mathematician's point of view.

Important as the study of Lithology has now become to geologists, we hope to see Mineralogy studied by them in a truly scientific manner, and this work we take as an indication that this has begun. Whilst taking exception to the way in which Mr. Milne has tried to avoid some of the difficulties of the subject—as on page 16, where the proof given applies only to those crystals belonging to four out of the six existing systems, and the results of which are used on page 25 in dealing with a crystal belonging to one of the two excluded systems—we cannot but admire his courage in publishing what has evidently been a labour of love, though beset with difficulties.

In the chapter devoted to the physical properties of crystals, a part needs careful revision by the author before its republication; no doubt, had Mr. Milne been in England, and able to consult authorities, this would have been more carefully treated. Of course Mr. Milne's notes are printed verbatim, the Editor not altering the author's work at all, save in a few trivial instances.

The woodcut figures are clear, and exceedingly well chosen.

As to the rest we consider that Mr. Milne has displayed considerable ingenuity in putting before his students in the way he has done a confessedly difficult subject, but into which those not versed in higher mathematics may yet hope to gain a fair insight.

The work has been seen through the press by Mr. Thomas Davies, F.G.S., who for twenty-one years has been attached to the Mineralogical Department of the British Museum, and is so well known to all petrologists and mineralogists on account of his intimate knowledge of these sciences.

II.—Syllabus of a Course of Lectures on Geology. (Cambridge University Extension.) 1873 to 1877. By W. J. Sollas, M.A., F.G.S. 8vo. (London, 1878.)

THESE Heads of Lectures will be very useful to students and teachers, as they are full and suggestive, and contain references to the principal works on each subject. The lectures embrace some matters more or less distinct from Geology proper, as those on the Atmosphere, Rain, and Snow; but it is not difficult to see their bearings on Geology, as also those of Astronomy, when we come to discuss the Evolution of the Earth. In this respect the series of lectures takes in a general scientific course, such as would be included in Physiography. A prominent feature is the attention given to the physical geography of past periods. The Permian beds, we may mention, are grouped with the Mesozoic rocks; and the Cambrian rocks are arranged according to the classification of Sedgwick. H. B. W.

III.—A Sketch of the Geology of Devonshire. By Townshend M. Hall, F.G.S. [Reprinted from White's History, Gazetteer, and Directory of the County.] 8vo. (Sheffield, 1878.)

IN the closely-printed seventeen pages of this sketch, Mr. Hall has given a very clear and condensed account of the Geology of Devon. The Devonian and Carboniferous rocks, which together occupy nearly two-thirds of the superficial area of the county, naturally receive a considerable share of attention, and the lists of fossils most commonly met with in their main divisions form a particularly valuable feature of this work.

The Triassic rocks, with their fossiliferous Budleigh pebbles, receive due attention; so also do the Cretaceous, Miocene, and Post-Tertiary deposits, including with the latter the Cave remains, the

Raised Beaches, and Submerged Forests. The Lias and Rhætic beds are dismissed with very little notice, although so well known at Axmouth and Axminster. The economic applications of the Igneous and Metamorphic rocks, as well as those of the stratified rocks, are pointed out; and a general account of the literature of Devonshire geology is given. In reference to this we may remind the author that it was J. J. Conybeare (not his more distinguished brother the Rev. W. D. Conybeare) who wrote on the geology of Okehampton and Clovelly. H. B. W.

REPORTS AND PROCEEDINGS.

Geological Society of London.—I.—June 11, 1879.—Prof. Joseph Prestwich, M.A., F.R.S., Vice-President, in the Chair.—The following communications were read:—

1. "On a Mammaliferous Deposit at Barrington, near Cambridge." By the Rev. O. Fisher, M.A., F.G.S.

The gravel in which these remains were found is about 20 feet above the alluvial flat by the River Rhee, and is evidently Post-glacial. The gravel contains some of the ordinary land and freshwater shells, but not *Cyrena* or *Unio*. Remains of the following Mammalia have been found:—*Ursus spelæus*, *Meles taxus*, *Hyæna spelæa*, *Felis spelæa*, *Cervus megaceros*, *C. elaphus*, and another, *Bos primigenius*, *Bison priscus*, *Hippopotamus major*, *Rhinoceros leptorhinus*, *Elephas antiquus* and *primigenius*, with a worked flint, almost certainly from the same deposit. The author considers the abundance and admixture of these remains due to the locality having been a sort of eddy or pool in the old river. The remains are described, and the rest of the paper is occupied with a correlation of the gravel with others in the adjoining district, and a consideration of the physical conditions under which it was deposited.

2. "Further Discoveries in the Cresswell Caves." By Prof. Boyd Dawkins, M.A., F.R.S., F.G.S., and the Rev. J. M. Mello, M.A., F.G.S., with Notes on the Mammalia by the former.

This paper contained the account of digging-operations carried on in one of the smaller caves of the Cresswell Crags, known as Mother Grundy's Parlour. The authors described the occurrence in the red clay and ferruginous sand of this cave of bones of Hippopotamus and the Leptorhine Rhinoceros, proving the existence of these animals in the wooded valleys of the basin of the Upper Trent at the time of the accumulation of these deposits; while at the same time, so far as the evidence goes, there was an absence of Palæolithic man, of the Reindeer, and of Horses, while Hyænas were abundant. In a subsequent period, represented in all the caves by the Red Sand, the Mammoth, Woolly Rhinoceros, Horse and Reindeer inhabited the vicinity, and were subject to the attacks both of Hyænas and human hunters, whose quartzite implements prove them to belong to the same people whose traces are found in the river-deposits. In the breccia and upper cave-earth of the larger caves the existence of the Palæolithic hunter is evidenced by flint implements, resembling those of Solutré, accompanied by implements of bone and antler. Associated with these was the incised figure of a horse described in a former paper. The authors finally dwelt briefly upon the characteristics of the caves in prehistoric and historic times, and indicated some of the anthropological points of interest connected therewith.

3. "On the Pre-Cambrian Rocks of Shropshire." Part I. By C. Callaway, Esq., D.Sc. Lond., F.G.S.

The author commenced by describing the physical geography of the ridges intervening between the vicinity of Wellington and the Longmynds, viz. Lilleshall Hill, the Wrekin, and the chain of the Caradoc Hills. He passed on to describe the stratigraphy. At Lilleshall are slaty beds dipping about N.N.W., and a rhyolitic agglomerate. At the N. end of the Wrekin a granitoid soil, probably of clastic origin, with a mass of decomposed intrusive rhyolite. The Wrekin consists of rhyolitic agglomerates, with (probably) lava-flows and a few basalt dykes, the general dip of the bedded rocks being to the north. At the southern end (Primrose Hill) granitoid gneisses (some closely resembling the hornblendic gneiss of Malvern) occur. In the Caradoc range intrusive greenstones are more largely developed; but here also are bedded Pre-Cambrian rocks. Other smaller exposures in this vicinity were also described. The prevalent strike is over the whole district about E.N.E.-W.S.W. The evidence of their age is often very clear, as they are overlain (with marked unconformity) by quartzites (sometimes containing rhyolitic fragments) which are clearly much older than the Hollybush Sandstones.

4. "On the Occurrence of a Remarkable and apparently New Mineral in the Rocks of Inverness-shire." By William Jolly, Esq., F.R.S.E., etc., and J. Macdonald-Cameron, F.C.S., etc.

In this paper the authors refer to a blue mineral of a somewhat remarkable character, which was specially noticed at an excursion of the Inverness Field Club in September, 1877. This excursion was made to Englishton Moor and neighbourhood, distant westwards, from Inverness, about five miles, where the mineral occurs in scattered blocks. It has since been noticed at Moniack Burn, Reelig Glen, and South Clunes Farm, all in the same direction, but distant from Inverness about ten miles; also near Dochfour House, at the north end of Loch Ness, close by Dochgarroch Lock on the Caledonian Canal. In colour and general appearance this mineral resembles crocidolite, but analyses point to its being more nearly related to ægirite, a member of the amphibole group, which has the general formula $Si3(\frac{1}{2}\ddot{R}7+R^3)$.

The mean of several analyses shows it to have the composition $6SiO_2$, Fe_2O_3, $2MgO$.

II.—June 25, 1879.—Prof. P. Martin Duncan, M.B., F.R.S., Vice-President, in the Chair.—The following communications were read:—

1. "On the Evidence that certain Species of *Ichthyosaurus* were Viviparous." By Prof. H. G. Seeley, F.R.S., F.G.S.

In this paper the author described certain specimens of Ichthyosaurs in which the remains of one or more small individuals have been preserved within the body-cavity of larger ones. One of these was described and figured in 1822 by Jäger; a notice of another was published in 1846 by Dr. Chaning-Pearce, who suggested that it furnished evidence in favour of the viviparity of the Ichthyosaurs.

Other examples are preserved in museums in Germany, and one in Madrid, and most of them have been examined by the author, who adduces the state of preservation of the small individuals, in contrast with that of the traces of fish and Cephalopoda, the remains of food, which are found in the stomachal region of the larger individuals, in advance of the position occupied by the smaller ones, as a proof that we have not here to do with a case of cannibalism. The position of the smaller skeletons, with the head generally turned towards the pelvic region of the larger ones, is also regarded as indicative of their standing in the relation of parent and offspring. As some of the young specimens possess limbs, it would seem that the supposition that *Ichthyosaurus* passed through a sort of tadpole stage is erroneous.

2. "On *Rhamphocephalus Prestwichi*, Seeley, an Ornithosaurian from the Stonesfield Slate of Kineton." By Prof. H. G. Seeley, F.R.S.

In this paper the author described the characters presented by the impression of the skull of an Ornithosaur in a slab of Stonesfield slate from Kineton, near Stow-on-the-Wold, the peculiarities of which are such as to induce him to found for it a new genus, to which he thinks it probable that most, if not all, the known Stonesfield-slate Pterodactyles may belong. It is distinguished especially by the great length of the roof of the skull posterior to the orbits, by the presence of a very deep constriction of the frontal region between the orbits, by the strongly marked sutures between the bones, and by the curiously Crocodilian character of the plan of structure of the roof of the skull, which suggests the existence of a lower grade of Ornithosaurian animals than has hitherto been suspected. The genus appears to be allied to some forms of *Rhamphorhynchus*. The author names the species, which is in the Oxford Museum, *Rhamphocephalus Prestwichi*, and considers that the other bones of Ornithosauria discovered in the Stonesfield slate support the generic separation of the group.

3. "A Contribution to South-American Geology." By George Attwood, Esq., F.G.S.

The paper describes a line of country in Spanish Guayana, Venezuela, S.A., commencing from a small town called "the Port of Las Tablas," on the Orinoco River, extending about 150 miles, and consisting of a series of crystalline and altered rocks. Syenite is the first rock met with; and then are found granite, quartz-diorite, hæmatite, and magnetic iron-ores, gneiss, slaty rocks, gabbro, and diabase. In the diabase the quartz-veins are found to contain large quantities of gold mixed with the vein-matter; the alluvial soil in the neighbourhood of the quartz-veins also contains gold nuggets and small grains of gold. Although quartz-veins are found in great numbers from the river to the interior, none of them have so far been found to contain gold in any appreciable quantity until the diabase is met with. All the rocks analyzed show a higher per-centage of silica than is generally found in other localities. Three analyses made from one piece of diabase showing two distinct lines of alteration by weathering (on the original rock), prove that silica is readily dissolved under atmospheric influences; whilst alumina is not. Iron oxides contain more oxygen near the surface than below it. Lime and magnesia are both readily soluble; but lime much more so than magnesia. Soda is more sensitive to weathering than potash. The rocks contain *more combined as well as uncombined* water on their surface than when sheltered from atmospheric influences.

The paper was accompanied by an appendix on the microscopical structure of some of the varieties of rocks by Prof. Bonney.

4. "On the so-called Midford Sands." By James Buckman, Esq.

The author quotes from the works of Professor Phillips and other authors certain passages, in which the sands below the Oolitic Limestones of the Cotteswold Hills and Dorsetshire are correlated with one another, and the name of "Midford Sands" is applied to the formation represented by these strata.

In opposition to these authors' views Prof. Buckman maintains that two distinct Ammonite bands have been by them confounded with one another; that the sandy beds in the Cotteswolds really belong to a much lower horizon than do the similar strata in Dorsetshire and Somersetshire; and that while the former lie quite at the base of the Inferior Oolite series, the latter represent a great part of that formation. In support of this view Prof. Buckman points to the fact that a representative of the true Cephalopoda-bed lies at the base of the so-called Midford Sands of Somersetshire; he illustrates the rapid transitions which take place between sandy and calcareous strata in this part of the series; and in conclusion he shows, by the study of the somewhat fragmentary fossils found in the sands of Dorsetshire and Somersetshire, that they are the true equivalents of several different divisions of the Oolites of the Cotteswold Hills. He admits, however, that some Liassic forms range upwards into these beds.

5. "On the Physical Geography of the North-east of England in Permian and Triassic Times." By E. Wilson, Esq., F.G.S.

In this paper the author seeks to utilize the information he has acquired from the study of the Permian and Triassic rocks of the above district, towards solving some of the difficult and much-debated questions as to their origin. With this end in view he traces the various members of the Magnesian Limestone formation between Notts and Northumberland, noticing in particular the amplification of that group of rocks in northerly and easterly directions. Incidentally attention is called to the increased importance of the Marl Slates as a distinct and characteristic series. One of the main objects of the paper is to establish the pre-Permian origin of the Pennine Chain. The nature and relative values of the stratigraphical breaks which, in the district in question, occur between the Carboniferous and Permian, the Permian and Bunter, and the Bunter and Keuper formations, are severally dealt with. The author concludes by speculating as to the general conditions under which the Permians may have been formed, and the physical fluctuations that may possibly have brought about the succession in one geological epoch of rocks so distinct in mineral constitution and in fossil contents as the Marl Slates, Magnesian Limestone, and Permian Marls.

6. "The Formation of Rock-basins." By J. D. Kendall, Esq., C.E.

The author discusses the mechanical difficulties involved in the glacier-excavation theory of lake-basins, and suggests that they are due to the action of falling water engulfed in the crevasses of the ancient glaciers, being thus of the nature of "giants' kettles," though on an enlarged scale.

7. "Diorites of the Warwickshire Coal-field." By S. Allport, Esq. The diorites are intrusive in the lower and unproductive measures of the above field and the underlying Millstone-grit below Atherstone and Marston Jabet (two miles south of Nuneaton). The author describes their microscopic characters. One variety is very finely crystalline and contains brown hornblende. Another contains plagioclase felspar with a little orthoclase, small crystals of brown hornblende, many crystals of clear yellowish augite, and several pseudomorphs after olivine, with apatite, magnetite, etc. A mineral also occurs belonging to the hexagonal system, which the author suspects to be nepheline. Other varieties are described, one of which contains augite with hornblende. These rocks differ considerably from the syenites of Leicestershire.

8. On *Lepidodiscus Lebouri*, a New Species of *Agelacrinites*, from the Carboniferous Series of Northumberland." By W. P. Sladen, Esq. The genus *Agelacrinites* was unknown in the Carboniferous rocks of Europe before the discovery of the fossil described in this paper; and even in the Silurian and Devonian rocks species referred to this group were exceedingly rare. The specimen now illustrated by the author, which belongs to the subgenus *Lepidodiscus*, was found by Prof. Lebour, and its study has thrown some new light on the structure and affinities of the genus. One of the most striking facts concerning it, now made out by the author, is that, like some recent forms of Echinoidea, the species would seem to have been so constructed as to permit of its plates overlapping, and thus to have been collapsible.

9. "On the Ancient River-deposit of the Amazon." By C. Barrington Brown, Esq., A.R.S.M., F.G.S.

The author described a series of alluvial deposits, varying in thickness from 10 to 160 feet, which have been cut through by the river, and form a series of cliffs, giving rise to striking and characteristic scenery. The succession of beds exposed in these cliffs was illustrated by a number of sections, and it was shown that the strata in question must have been deposited by river-action. It was then pointed out that the river is performing two classes of work, namely, cutting away the older sheets of alluvial matter, and depositing the materials derived from them at a much lower level. The interesting phenomena of the cutting of curves by the river, and the abandonment by the river of parts of these curves, giving rise to the formation of lakes, was fully explained; and in conclusion the author showed by a map what vast areas in South America have thus been covered by these alluvial deposits.

10. "The Glacial Deposits of Cromer." By Clement Reid, Esq. In this paper the author described the beds shown in the cliffs between Weybourn and Happisburgh. The classification adopted was:—

Sands and Gravels (Middle Glacial?).
Bedded sand and marl. } Contorted Drift.
Sedimentary Boulder-clay. }
Fine Sands.
2nd Till (unstratified Boulder-clay).
Intermediate Beds (laminated marl, etc.).
1st Till (unstratified Boulder-clay).
Arctic Freshwater Bed.

The beds below the 1st Till were not described: the 1st and 2nd Tills were considered to have been formed by land-ice coming from the W. or W.N.W.; while the Intermediate Beds appear to be stratified glacier-mud deposited on the retreat of the ice. The Sands are probably marine, and so also appear to be the Contorted Drift and Middle Glacial. Glacial Beds later than the Chalky Boulder-clay appear to be represented near Cromer by valley-deposits which were not treated of in this paper. In dealing with the question of the age and mode of formation of the contortions, the author pointed out that all, with the doubtful exception of a few of the smaller ones, affected not only the Contorted Drift, but also the Middle Glacial; while, at the same time, contortions affecting the overlying beds were often much more complicated at the base, and rested on an even, undisturbed surface of the Preglacial beds. This he accounted for by considering the contortions to be formed by an advancing ice-sheet, which pushed before it a mound of the older glacial beds, while the beds below the level of the base of the ice were undisturbed; thus the junction of the contorted and uncontorted beds is a horizontal fault-line. The ice-sheet he referred to the period of the Chalky Boulder-clay. The author drew attention to the fact that the hollows in which the Middle Glacial gravels rest are in every instance due to contortion and not to erosion. The large masses of Chalk in Boulder-clay were considered to have been torn off by the same force that produced the contortions.

11. "On a Disturbance of the Chalk at Trowse, near Norwich." By Horace B. Woodward, Esq., F.G.S.

Attention was drawn to a section at Trowse, where the Chalk with bands of flint was uplifted at an angle of about 37°. Abutting against the Chalk was a mass of the same rock rearranged, containing broken flints, and pebbles of flint, quartz, and quartzite. This rearranged Chalk was traced underneath the uplifted beds; and the author gave reasons for believing that the disturbance was produced by the agent (land-ice) which formed the Chalky Boulder-clay. Allusion was made to many cases of glaciated Chalk in Norfolk, and to the cervine and other organic remains occasionally met with in it. Comparing the Trowse section with that at Litcham, described by Mr. S. V. Wood, Jun., the author came to the conclusion that this was a similar and striking instance of the incipient formation of a huge Chalk boulder, serving to throw light on the origin of the large transported masses seen in the Cromer Cliffs.

12. "The Submerged Forest of Barnstaple Bay." By Townshend M. Hall, Esq., F.G.S.

Traces of an old forest-bed exist in many places beneath the Braunton Burrows, on the shore of Barnstaple Bay. Some good sections were exposed near Westward Ho after the winter of 1863–4 owing to an inroad of the sea, trees being found in the position of growth. They were mostly oak, and a few pine or fir, with an undergrowth of hazel, with probably *Betula nana*, and with moss and leaves of an *Iris*. The author gives details of the sections of kitchen-midden deposits with flint-flakes and cores, pointed stakes, split bones, etc. Bones of the red deer, roebuck, goat, hog, wolf, and *Bos longifrons* have been found associated with the peat.

13. "On a Section of Boulder-clay and Gravels at Ballygalley Head, and an inquiry as to the proper classification of the Irish Drift." By T. Mellard Reade, Esq., C.E., F.G.S.

The section described is in a gravel-pit about 30 feet deep, situated between Larne and Cushendall, in the north of Ireland. It shows a considerable thickness of false-bedded gravel and sand, containing shells, covered by Boulder-clay. The shells collected from the sand and gravel of this section do not, however, agree with those found in the so-called "Interglacial beds" of Lancashire; and the author regards the section as confirming his views that the tripartite division of the drift-deposits is not, as maintained by Hull and other geologists, equally applicable to the Irish and Lancashire deposits.

14. "On the Augitic Rocks of the Canary Islands." By Professor Salvador Calderon. Communicated by the President.

As the result of a long investigation of the eruptive rocks of the Canaries, and especially of Las Palmas, the author has come to the conclusion that there are two groups of such rocks in those islands, an older one, characterized by the presence of hornblende, and a newer, containing augite. In the latter he finds the essential minerals to be plagioclase, augite, magnetite, olivine, sanidine, and nepheline; and he distinguishes among them the following kinds of rocks, all of which have their characteristic minerals imbedded in a paste of augite and plagioclase:—1. *Augite-andesite*, with a small quantity of sanidine; 2. *Tephrine*, with no sanidine, but abundance of nepheline; 3. *Basanite*, with some peridote; 4. *Nepheline-basalt*, with abundance of peridote; 5. *Dolerite*, crystalline, characterized by the disappearance of nepheline, the abundance of peridote and porphyritically imbedded plagioclase, and with porphyritically imbedded individuals of augite and olivine; 6. *Felspathic basalt* (like 5), but semicrystalline; and 7. Essentially olivinic modern lavas.

15. "On the Cambrian (Sedgw.) and Silurian beds of the Dee Valley, as compared with those of the Lake-district." By J. E. Marr, Esq., B.A., F.G.S.

The principal differences in these districts appear to be due, (1) to the non-correspondence of the epoch of volcanic activity, (2) to the upheaval and consequent denudation of a part of North Wales after the end of the Cambrian period. The author correlates the deposits in the two areas, the Dee valley having deposits parallel to the various members in the Lake-district, from the Skiddaw Slates to the Upper Coldwell beds inclusive. The Lower Bala series contains ash-beds which appear to be andesitic. In the Middle Bala of Wales are some fossils which, in the Lake-district, occur in the Ashgill Shales above the Coniston Limestone. He finds the equivalents of the Graptolitic Mudstone of the Lake-district, near Carrig-y-druidion, corresponding in stratigraphical position, lithological character, and fossils. One Graptolite, *G. colonus*, however, occurs at a higher horizon in the Lake-district. In the lowest division of the Denbigh Grits *Acroculia haliotis* is found, which, in the Lake-district, occurs in the Upper Coldwell beds; and in the uppermost series there are other fossils which occur in the Bannisdale Slates and Kirkby-Moor Flags, thus giving further indications of a northward migration.

16. "On some Superficial Deposits in the Neighbourhood of Evesham." By the Rev. A. H. Winnington Ingram, M.A., F.G.S.

The lower series of gravels on Green Hill contains unworn flints about 10lbs. in weight. They are about 120 feet above the level of the Avon, and were probably brought by floating-ice. A clay at Bengeworth, beneath a sand with *Unio ovalis* (60 feet above the Avon), has yielded entire heads and horns of *Bos primigenius*, *Bison priscus*, an antler of *Cervus tarandus*, and a tooth of *Hippopotamus*, with other mammalian bones. A similar clay on the opposite side of the river at Evesham has furnished *Cervus tarandus* and river-shells, etc.

17. "Descriptions of Palæozoic Corals from Northern Queensland, with Observations on the Genus *Stenopora*." By Prof. H. A. Nicholson, M.D., D.Sc., F.G.S., and R. Etheridge, Esq., Jun., F.G.S.

The Corals described in this paper were in part collected by the late Mr. Daintree, chiefly from the limestone of the Broken River, regarded as of Devonian age, and in part by Mr. R. L. Jack from various sources, namely, the Bowen-river Coalfield, in beds probably of Permo-Carboniferous age, the Fanning-river Limestone (Devonian), and the Arthur's-creek Limestone (Permo-Carboniferous). Mr. Daintree's collection also contained corals in the chloritic rock of the Gympsie Goldfield. From the Coral Creek, Bowen-river Coalfield, the authors record *Stenopora ovata*, Lonsd., and *S. Jackii*, sp. n.; from the Fanning-river Limestone, *Heliolites porosus*, Goldf., and *Pachypora meridionalis*, sp. n.; from the Gympsie chloritic rock *Stenopora* ? sp. ind.; from the Broken-river Limestone, *Favosites gothlandicus*, vars. Lam., *Heliolites porosus*, Goldf., *H. plasmoporoides*, sp. n., *H. Daintreei*, sp. n., *Heliolites* sp. ind., and *Aræopora australis*, sp. n.; from the Arthur's-creek Limestone, Burdekin Down, *Alveolites* (*Pachypora* ?), sp., near *A. robustus*, Rom., *Alveolites* sp. (lobate form), *Aulopora repens*, M.-Edw. & H., *Heliolites porosus*, Goldf., and vars., *Lithostrotion* sp. ind., *Pachypora meridionalis*, *Trachypora* sp. ind., and species of *Cannopora* and *Stromatopora*. The genus *Aræopora* is proposed as a new group; the genus *Stenopora* is made the subject of a long discussion; and the geological characters of the deposits from which the fossils are derived are indicated and discussed.

The SOCIETY *then adjourned to November 5th.*

CORRESPONDENCE.

LENTICULAR HILLS OF GLACIAL DRIFT.

SIR,—In the June Number of the GEOLOGICAL MAGAZINE Mr. Warren Upham asks whether British geologists have noted accumulations of Till like the "lenticular hills" of Prof. Hitchcock. The description given of these hills answers precisely to that given by Messrs. Kinahan and Close, in their paper on the "General Glaciation of Yar-Connaught," of the "drum-lines" of unstratified Boulder-clay.

Mr. James Geikie, also, in his "Great Ice Age," says that "in lowland tracts the till is frequently arranged in long round-backed ridges, which are parallel to one another and to the direction of the principal valley of the district."

Similar mounds are equally common in many parts of the Yorkshire dales: they occur, for instance, in Bishopsdale, Wensleydale, and Ribblesdale, and on the Haws between the latter dale and Wharfdale. In Westmorland, too, such mounds are common at the foot of the mountains, and they form a striking feature in the landscape of the low ground near Kendal. J. R. Dakyns.

Bridlington Quay.

FAULTS IN THE LONDON CLAY, NEAR HARWICH.

Sir,—The extensive excavations now going on at Ray Island, near Harwich, where the new docks are being constructed for the Great Eastern Railway Company, have exposed some splendid banded sections of the London Clay. One of these is plainly visible to the railway traveller, on the left-hand side, about a mile before he reaches Dovercourt Station. As nearly the whole of the humpy mass of land now called Ray Island is intended to be carried into the neighbouring estuary of the Stour for the erection of embankments, a notice of the dislocations now visible in the sections is of geological value.

In many places the London Clay is seen to be thrown into a series of very gentle folds. At no fewer than *nine* places in the section, small faults are as plainly visible as in a geological diagram, owing to the banded character of the strata. With one exception all the faults have an angle of about fifty degrees, the exceptional fault (seen in the railway cutting) being nearly vertical. The latter shows a dislocation of about two feet. The largest fault is visible in that end of the railway cutting nearest to Dovercourt, and measures upwards of twelve feet. A fault of more than eight feet is seen in a section near the estuary, and some of the minor dislocations occur at intervals of from fifty to one hundred yards. The line of fault is in most instances as sharply defined as if the strata had been diagonally cut through with a knife. J. E. Taylor.

PYRITIFEROUS SAND FROM LAKE WINNIPEG.

Sir,—I have had a sample of somewhat curious sand put in my hands by a man who has recently returned from America, and venture to think it may elicit some further information about it could you find space for my note. I send a sample of the sand; you will see that it consists of a very fine grained siliceous sand, grey in colour, the greyness being due to an innumerable quantity of almost microscopic concretions of pyrites. Under the microscope these are pretty objects, mostly globular, and when broken show very distinctly their concentric structure; they appear very similar on a minute scale to the concretions so commonly met with in the Cretaceous deposits, etc. Possibly they have formed round a foraminiferous or other organic nucleus, but I have not succeeded in detecting it as yet in any of the broken globules.

The locality from which the sand was brought is said to be on the

North shore of Lake Winnipeg, the section exposed being a natural one, and is as follows:—

1. Loam, 3ft.
2. Hard rock (Limestone?) 10ft.
3. Pyritiferous sand, silvery to the eye when fresh, 4ft. (exposed).

The pyrites forms so large a portion of the sand that it might be worth while to work the deposit; mere washing would probably separate the ore readily from its matrix. The composition of the pyrites is said to be Fe 46·4 S 53·6.

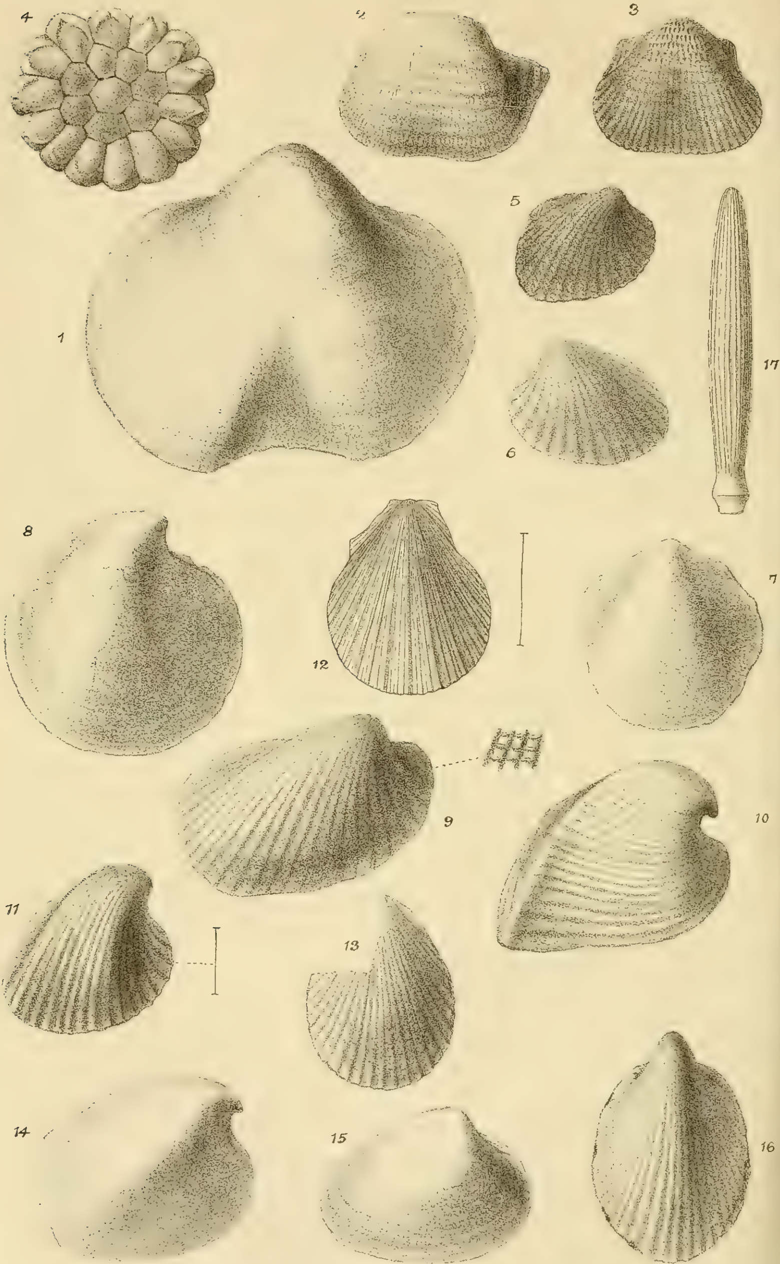
With regard to the origin of the pyrites, can it have been formed in situ in the sand, or is it as well as the sand the product of the disintegration of an older rock? I can find no account of any similar deposit elsewhere; the nearest approach to such a bed in character seems to be met with in beds containing diminutive spherical nodules of iron ore in Manitoba, but these are not pyrites; they are chalybite and much larger; and it is said in the report of the Survey of the 49th Parallel, that a thin film of pyrites in the Lignite deposits near Porcupine Creek was the first appearance of that mineral in connexion with those deposits. J. Magens Mello.

The Rectory, Brampton, S. Thomas,
Chesterfield, *June* 28, 1879.

GLACIATION OF THE WEST YORKSHIRE DALES.

Sir,—Will Mr. J. W. Davis kindly tell us what evidence he has to show that either the Scotch or Lake Country ice, after traversing the valley of the Eden, passed down Wensleydale, Arkendale, and Swaledale, as stated by him in your last Number, p. 315? I think the statement must be new to most of your readers, unless they have seen a somewhat similar one in Davis and Lee's West Yorkshire. Surely if the ice took this course, these dales should abound in erratics. Yet so far as I know there are no foreign boulders in Wensleydale—only local ones. There are no erratics in Arkendale and none in Swaledale, except in the lowest part of the dale near Richmond, where it can be shown clearly that they came over the watershed from the north, out of Teesdale. Mr. Davis must have entirely misunderstood Mr. Goodchild's paper on this matter. It may look at first sight to an outsider as if the ice ought to have behaved differently, especially when it did not pass from the Eden Valley over the low watershed into Wensleydale. "But facts are chiels that winna ding." Perhaps it is not generally known that the Lake Country ice in passing over Stainmoor did not take the direction of the lowest pass, 1378 feet above the sea, and so cross where the Stainmoor railway goes over into the valley of the Greta, but it passed over higher ground further north into Deepdale, Balderdale, and Lunedale, and erratics have been found by Mr. Goodchild and myself at various heights up to 1800 feet on the watershed between the Eden and the Tees. W. Gunn,

Berwick-on-Tweed, Geol. Surv. of Eng. and Wales.
July 12, 1879.



C. L. Griesbach del. et lith. West, Newman & Co. imp.

Sumatran Fossil Shells, &c.

THE
GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. VI.

No. IX.—SEPTEMBER, 1879.

ORIGINAL ARTICLES.

I.—Notes on a Collection of Fossil Shells, etc., from Sumatra (obtained by M. Verbeek, Director of the Geological Survey of the West Coast, Sumatra). Part I.

By Henry Woodward, LL.D., F.R.S., F.G.S., etc.;
of the British Museum.

(PLATE X.)

FOUR years ago M. R. D. M. Verbeek, Director of the Geological Survey of the West Coast, Sumatra, placed in the hands of my friend Prof. T. Rupert Jones, F.R.S., for description, a collection of fossil remains obtained by him in the prosecution of his geological researches in Central Sumatra, accompanied by some notes and sections of the geology of this little-known region of the globe.

These notes have already appeared,[1] and a portion of the fossil remains has also been published in this Journal.[2] It is now proposed, as far as practicable, to complete the description of the Invertebrate remains forwarded by M. Verbeek, to illustrate which six excellent plates have already been drawn by Mr. C. L. Griesbach, F.G.S.[3]

Palæozoic Rocks.—The oldest rocks of Central Sumatra appear to consist of granites, granite-syenites, and syenites in several modifications. Next in order follow sedimentary rocks, which are probably of either Carboniferous or Permian age, as they contain *Fusulinæ*, only met with in rocks belonging to the Carboniferous and Permian periods (Verbeek, op. cit. p. 478).

The species of *Fusulina* from the Carboniferous Limestone, Padang Highlands, West Coast of Sumatra, has been referred by Mr. H. B. Brady to *Fusulina princeps*, Ehrenberg, sp. (see Geol. Mag. 1875, p. 537, Plate XIII. Figs. 6 *a*, *b*, *c*). The only other Palæozoic fossils which remain to be noticed are represented on our Plate X. Figs. 1, 2, and 3, Brachiopoda belonging to the genera *Spirifera* and *Productus*.

[1] See Geol. Mag., 1875, Decade II. Vol. II. pp. 477-486, and op. cit. 1877, Dec. II. Vol. IV. pp. 443-444 (Plate XIV.).

[2] The Fossil Foraminifera, by Henry B. Brady, F.R.S., Geol. Mag., 1875, Dec. II. Vol. II. pp. 532-539 (Plates XIII. and XIV.). The Fossil Fishes, by Dr. A. Günther, V.P.R.S., Geol. Mag., 1876, pp. 433-440 (Plates XV.—XIX.).

[3] This memoir and its illustrations are, like the former communications, published with the authority and assistance of the Dutch-Indian Government.

1. *Spirifera glabra*, Martin, sp., 1809. Pl. X. Fig. 1.

This very variable and widely distributed species is amply illustrated in Mr. Davidson's great work on "British Fossil Brachiopoda," vol. ii. Permian and Carboniferous species (1858–63), pp. 59–62, pl. xi. and xii. The following description of the species is given by Mr. Davidson in his Palæontographical Monograph above cited:—"Transversely oval, rarely as long as or longer than wide. Valves almost equally convex, with a mesial elevation or fold in the dorsal, and a sinus in the ventral valve. Hinge-line much shorter than the greatest width of the shell; cardinal angles rounded; beaks rather approximate, that of the larger or ventral valve prominent, incurved, and of moderate dimensions. A hinge area in the dorsal valve, that of the ventral one triangular or of moderate dimensions, with its lateral margins more or less sharply defined; fissure partially covered by a pseudo-deltidium. The mesial fold in the dorsal valve is either slightly and evenly convex rising gradually from the lateral portions of the valve, or abruptly elevated, with a longitudinal depression along its middle, which is also at times reproduced in the sinus of the ventral one. The spiral appendages are large, and occupy the greater portion of the interior of the shell. Surface of valves in general smooth, but sometimes a few obscure rounded ribs may be observed on their lateral portions."

The largest of our Sumatran specimens (that figured in Pl. X. Fig. 1) accords most nearly with Mr. Davidson's fig. 8, pl. xi., but is broader in proportion to its length; being 19 lines in length and 24 lines in width. The surface of the shell is smooth. One specimen sent exposes the interior of the ventral valve and exhibits evidence of the spiral appendages.

Distribution:—*Spirifera glabra* has an extremely wide distribution, being recorded from Britain, Ireland, Belgium, France, Russia, America, Australia, and Sumatra.

[For the identification of this and the following Carboniferous forms, I am indebted to my colleague Mr. R. Etheridge, jun., F.G.S., who has paid special attention to the fauna of the Carboniferous epoch.]

2. *Productus undatus*, Defrance, 1826. Pl. X. Fig. 2.

Davidson, Brit. Carb. Brach. (Pal. Soc. Mon.), 1861, Pt. V. p. 161, pl. xxxiv. figs. 7–13.

The following specific characters are given by Mr. Davidson:—"Shell somewhat sub-orbicular or slightly transverse, hinge-line rather less than the width of the shell. Ventral valve regularly vaulted, very convex, without sinus; beak small, rounded, incurved, not extending much beyond the hinge-line; auriculate expansions small. Surface covered with numerous irregular or interrupted sub-parallel, undulating, concentric folds or wrinkles, which become wider and more produced with age and having their narrow, almost perpendicular, side directed towards the beak; the valve is, moreover, ornamented by numerous minute, rounded, thread-like striæ, separated by narrow sulci, and of which from five to six may be counted in the thickness of a line, and swelling out at intervals they give rise to a slender spine. Dorsal valve concave, following the curves of the opposite one, and similarly ornamented. Interior unknown."

Distribution:—Britain, Ireland, Belgium, Russia, Tasmania, New South Wales, and Sumatra.

3. *Productus semireticulatus*, Martin, sp. Pl. X. Fig. 3.

Davidson, Brit. Carb. Brach. (Pal. Soc. Mon.), 1861, Pt. V. p. 149, pl. xliii. figs. 1–11, and pl. xliv. figs. 1–4.

The subjoined specific description is taken from Mr. Davidson's monograph:—"Very variable in shape, transversely oval, sub-cylindrical or elongated; hinge-line as long as, or somewhat shorter than the width of the shell; ventral valve gibbous and variably vaulted, with a shallow longitudinal median sinus or depression; auriculate expansions moderately developed; beak wide, incurved, usually covered with irregular, concentric, undulating wrinkles, larger and deeper upon the ears, while the entire surface of the shell is ornamented by many radiating, longitudinal, rounded striæ, which become more numerous towards the margin from bifurcation and interstriation and from which project, at variable intervals, tubular spines of sometimes considerable length. Dorsal valve moderately concave, following the curves of the opposite one, and similarly sculptured. Dimensions variable, some examples having attained three inches in length, by four in breadth."

Distribution:—Great Britain and Ireland, Belgium, Germany, Russia, Spitzbergen, Punjaub, Australia, North and South America, and Sumatra.

4. *Productus costatus*, J. de C. Sby., 1827. (Not figured.)

Davidson, Brit. Carb. Brach. (Pal. Soc. Mon.), 1861, Part V. p. 152, pl. xxxii. figs. 2–9.

Although unintentionally omitted from our Plate, we must not fail to record this species from the Carboniferous rocks of Sumatra.

We subjoin the specific description of this form given by Mr. Davidson:—"Shell very variable in shape, transversely semi-cylindrical, wider than long; hinge-line about as long as the width of the shell. Ventral valve gibbous, very much vaulted, abruptly arched, or obscurely geniculated; beak incurved, but not overlying the hinge-line, except at its attenuated extremity, a median longitudinal sinus or depression dividing the valve to a greater or less extent into two lobes; ears more or less developed, sloping abruptly from the visceral portion, with a strong, rugged, semicircular ridge on either side, obliquely placed to the hinge-line, and from which project several long, cylindrical hollow spines, similar to those situated close to the cardinal edge. Surface covered with a variable number of strong, longitudinal, rounded ribs of unequal width, and which become more numerous towards the margin from occasional bifurcation or intercalation, while the whole visceral portion is crossed by numerous regular concentric wrinkles, producing reticulate tuberculations. The spines are long, but variable in number, projecting here and there from the ribs. Dorsal valve somewhat geniculated, following the curves of the opposite valve, a slight median elevation corresponding to the sinus of the ventral valve; the visceral portion is usually somewhat flattened, while the anterior portion of the valve becomes more or less abruptly bent upwards; the sculpture being similar to that of the opposite valve."

Distribution:—This species is recorded as occurring in Great Britain and Ireland, in Belgium, Russia, North America, the Punjaub, and in Sumatra.

This concludes our notes on the Palæozoic fossils of Sumatra, and we pass on to consider those of later date.

5. *Pecten*, sp. Pl. X. Fig. 12.

This species is represented by a single minute example, having both valves united. The ribs upon one side have every second or third more prominent with one or more intermediate smaller ribs. On the opposite valve they are rather more uniform in size.

We do not propose to name this species.

Formation and Locality:—Tertiary Limestone, Sumatra.

6. *Pecten*, sp. Pl. X. Fig. 13.

As only a portion of one valve is preserved, this specimen is too imperfect to afford justification for specific description. The valve exhibits about 24 rounded ribs broader than the interspaces, which contain traces of fine linear striæ.

Locality and Formation—Tertiary Marl-clay, Island of Nias.

7. *Arca Verbeekii*, H. Woodw. Pl. X. Fig. 9.

Shell subquadrate—inequilateral, beaks prominent and anterior, hinge-area moderately wide, between 20 and 24 strongly imbricated ribs of about the same width as the interspaces—posteriorly oblique. This form approaches most nearly to *A. diluvii*, Lamk.

It affords me much pleasure to dedicate this elegant form to Mynheer R. D. M. Verbeek, by whom it was collected.

Locality and Formation:—From the clay-marls of (probably) Miocene age. Island of Nias, Government of the West Coast of Sumatra.

8. *Hemicardium*, sp. Pl. X. Fig. 11.

A somewhat gibbose triangular shell having 12–14 rounded costæ, posteriorly subcarinated and depressed as in the ordinary forms referred to this section of *Cardium*.

Locality and Formation:—From the Miocene Clay-marls, Island of Nias, Government of the West Coast of Sumatra.

9. *Lunulocardium limaforme*, H. Woodw. Pl. X. Fig. 16.

This is a gibbose elongate shell with prominent umbones, slightly recurved, having numerous rounded ribs, traces of which are, however, only faintly shown in the casts. Impressions corresponding with the central and lateral teeth, and of the adductor muscles, are also to be observed in the casts.

I am unable to refer this shell to any already-described form, and have ventured, therefore, to treat it as a new species. There are several specimens, that figured in our Pl. X. Fig. 16, being one of the smallest. Size of largest valve: Long. 55 mm.; Lat. 40 mm. Size of smallest valve: Long. 30 mm.; Lat. 22 mm.

Locality and Formation:—From the Miocene Clay-marls, Island of Nias, Government of the West Coast of Sumatra.

10. *Lucina*, sp. (cast). Pl. X. Fig. 7.

This is evidently a cast of *Lucina*, but the state of preservation precludes the possibility of offering an opinion as to the species to which it should probably be referred.

Locality and Formation:—This cast was obtained from Government of the West Coast of Sumatra, "Stage 5" of M. Verbeek, Coral-limestone "including internal casts of Gasteropods and Conchifers, together with *Echinidæ* comparable with the Eocene forms *Prenaster Alpinus*, Desor, and *Periaster sub-globosus*, Desor." (Verbeek, Geol. Mag. 1877, p. 444.)

Gen. *Isocardia*, Lamarck, 1799.

Shell cordate, ventricose; umbones distant, sub-spiral; ligament external; hinge-teeth 2:2; laterals 1–1 in each valve, the anterior sometimes obsolete. Of this genus five species are recorded from Britain, Mediterranean, China, and Japan, and 70 fossil species from the Trias and higher formations.

H. and A. Adams, in their Genera of Recent Mollusca, 1858, vol. ii. p. 461, have proposed, for certain forms of *Isocardia*, a subgenus.

Sub-genus *Meiocardia*, H. and A. Adams, 1858.

"Shell with the surface of the valves concentrically grooved, not covered with an epidermis." (Valves strongly carinated at the posterior end, forming a prominent acute diagonal ridge. Posterior slope concave.) To this subgenus has been referred:—*M. Lamarckii*, Sby.; *M. Moltkiana*, Chem.; *M. Cumingii*, A. Ad.; *M. tetragona*, Adams and Reeve; *M. vulgaris*, Reeve; all recent forms: also *M. Guerangeri*,[1] d'Orb. (Cénomanien), Chloritic marl of Le Mans; and *M.* (*Isocardia*) *pyrenaica*, d'Orb., from the Cretaceous of Corbières, Aude, France. This latter form, however, we should be more inclined to refer to the genus *Opis*.

11. *Meiocardia sub-Cumingii.* Pl. X. Fig. 10.

Of the various species of *Meiocardia*, it is very interesting to observe that the recent *M. Cumingii* from China seems almost identical with our fossil; the only perceptible variation being that in the recent form the raised concentric ridges are about 24 in number, whereas in the fossil there are upwards of 30. In the fossil form the diagonal ridge is even more prominent and acute than in the recent species, and the posterior slope more concave. These are the only points deserving of special attention—save that one of the fossils (casts) is much larger than the recent form; probably half as large again as the specimens of *M. Cumingii* from China in the British Museum.

[1] Not mentioned in the text of d'Orbigny; but marked on his plate 257bis. as "*Isocardia Guerangeri*, d'Orb." In his Prodrome de Paléontologie Stratigraphique Universelle, vol. ii. 20 Etage Cénomanien, No. 290, p. 160, however, he enters it as "*Opis Guerangeri*, d'Orb, 1843."

I have to express my obligation to my colleague, Dr. A. Günther, F.R.S., Keeper of the Zoological Department, for permission to compare and examine the recent species of *Meiocardia* in the Collection.

Measurements of *Meiocardia sub-Cumingii*:—Length of valve of smaller specimen 21 mm., width 22 mm. Length of valve of largest specimen 30 mm., width 25 mm. Length of valve of *Meiocardia Cumingii* 20 mm., width 20 mm.

12. *Cardita Sumatrensis*, H. Woodw. Pl. X. Fig. 5.

This species presents some affinity to *Cardita Schwabenaui*, Hörnes, and also to a form from the St.-Cassian Beds.

Shell quadrate, anterior slightly rounded, posterior straight, ribs 15 to 17 in number, carinated and imbricated, the intermediate spaces being much wider than the ribs.

Width of valve 20 mm., length 16 mm.

This is a most abundant shell occurring closely packed upon the surface of *yellow* argillaceous slabs, feeling like "steatite" to the touch.

Locality and Formation:—Tertiary, Sumatra. Probably from the clay-band associated with Sandstones and Coals (5 *b*) described by M. Verbeek (Geol. Mag. 1875, p. 479).

13. *Cardita*, sp. (cast). Pl. X. Fig. 6.

This specimen appears to have been somewhat more coarsely ribbed than the preceding, and the umbones of the valves rather more produced; but the specimen is too much abraded to determine satisfactorily.

Width of valve 21 mm., length 19 mm. Cast in limestone (No. 5), Verbeek, Geol. Mag. 1877, p. 444. Eocene? Tertiary, Sumatra.

14. *Cytherea*, sp. (cast). Pl. X. Fig. 15.

Only a single valve preserved as a cast, which is referable to the genus *Cytherea*.

Locality and Formation:—From the Miocene Clay-marls, Island of Nias, Government of the West Coast of Sumatra.

15. *Callista*, sp. (cast). Pl. X. Fig. 14.

A cast of a compressed sub-quadrate shell, with the umbones prominent and very anterior, lunule deep (no muscular impressions visible, hinge-line long); below which the shell is slightly grooved.

Locality and Formation:—From the Miocene Clay-marls, Island of Nias, Government of the West Coast of Sumatra.

16. *Dosinia cretacea*, Reeve (cast). Pl. X. Fig. 8.

Reeve (1850), Conch. Icon., sp. 35 (*Artemis*), pl. vi. fig. 35. Sowerby, Thesaurus Conch., 1855, vol. ii. p. 667, No. 46, t. 142, fig. 51.

My colleague, Mr. Edgar A. Smith, who has most obligingly compared this and other fossil specimens with the recent shells in the Zoological Gallery for me, remarks:—"These casts agree remarkably well with the recent *Dosinia cretacea*, Reeve. The form, the depth and size of the lunule, and the shape of the muscular impressions as far as traceable, are identical."

The following is the description of this species translated from Dr. Eduard Römer's Monograph on the Molluscan genus *Dosinia*, Scopoli (*Artemis*, Poli), 1862, 4to. p. 34.

Shell suborbicular, somewhat tumid, thick, very inequilateral, rather flexuous posteriorly, finely and regularly striated concentrically; striæ at the sides, especially posteriorly, more elevated; chalky white, sometimes straw-coloured towards the umbones; umbones rather tumid, occupying one-fourth the length; ventral margin semicircular at both extremities, very steep; anterior dorsal margin very short; posterior sloping moderately behind and curved; lunule cordiform, impressed, striated, sharply circumscribed; area somewhat large, slightly excavated; ligament conspicuous; nymphæ slender; pallial sinus large, narrow, triangular, apex rather acute, terminating nearly horizontally at the upper edge; cardinal lamina narrow; lateral teeth large, papilliform; cardinal tooth perpendicular, slender, greatly thickened; last tooth in right valve very remote, slender, superficially bisulcated, median pit very large.

This species is found living at Manilla, at the Island of Luzon, Philippines. Our fossil specimens are derived from the so-called Miocene Marl-clays of the Island of Nias, Government of the West Coast of Sumatra.

17. ECHINODERMATA. Spine of *Cidaris?* Pl. X. Fig. 17.

There are several of these spines from the locality mentioned below. They appear to be referable to a species of *Cidaris*, but as they are much worn, and as no plates of the test are associated with them, it would be difficult to correctly assign them to any specific form.

Locality and Formation:—From bed 5, Coral-limestone, with casts of Gasteropods and Conchifers, together with *Echinidæ* (see GEOL. MAG. 1877, p. 444), Padang Highlands, Government of the West Coast of Sumatra.

PLANTÆ.—*Sparganilithes*, gen. nov.

18. *Sparganilithes gemmatus*, H. Woodw. Pl. X. Fig. 4.

This anomalous fossil remain was obtained from the division marked No. 3 by M. Verbeek, who thus describes it (see GEOL. MAG. 1877, p. 444): "*Sandstones* with *Coal-seams*, without organic remains, nearly 1,000 feet thick, resting unconformably on the Marl-shales. The only fossils in them are undeterminable stalks and leaves of plants, small *Melaniæ*, and traces of fish."

The *Melaniæ* are so abundant as to form almost the entire substance of some of the shale-bands with their compressed shells. The species closely resembles *Melania crebricostata* in size and ornamentation; but is rather more strongly corrugated. The lime of the shells has been entirely dissolved away and removed, only the impressions remaining in the shale.

At first sight it appeared difficult, if not impossible, to refer the fossil figured in our Plate (Fig. 4) to any known group or organism with certainty. The specimens are three in number, being found in dark, fine-grained, thinly-laminated, and bituminous coal-shale, apparently detached from any other organism. The organism consists of a disc-like polygonal body, surrounded, in one instance, by six, in another by seven similar plates, and these again encircled by from thirteen to fourteen similar but somewhat adpressed plates or scales forming the outer circle. The surface of each separate plate or scale is covered with a thin crust of pure coal, which is seen also to pass down and penetrate between each separate polygonal body.

In one specimen the central plate is absent, but six closely pressed plates meet and fill up the interior of the disc, whilst the border is composed of fourteen slightly elongated adpressed plates.

Whilst engaged in the examination of this fossil, and instituting comparisons with various other organisms, my friend Professor Morris made the happy suggestion that I should compare it with the fructification of *Sparganium ramosum.*

Having been kindly permitted by my colleague Mr. W. Carruthers, F.R.S., to consult the Herbarium under his charge, I was delighted to find that the fruit upon dried specimens of *Sparganium ramosum* was, after lateral compression, almost identical in appearance with our fossil, as well seen in the enlarged figure on our Pl. X. Fig. 4. Even the slight ridges, represented on the outer circle of seeds in our figure, are seen in the dried and *compressed* prismatically arranged drupe of *Sparganium.* Of course the fossil does not represent an entire fruit.

The following is the description of *Sparganium ramosum,* Hudson, given in Sowerby's 'English Botany,' 1869, vol. xi. p. 5 : "Radical leaves broadly linear, stiff, not floating, sharply keeled and triquetrous at the base, with the lateral faces channeled ; stem-leaves with their sheaths not inflated. Flowering-stem erect, stiff, branched at the apex. Flower-heads in a panicle. Female flower-heads sessile on the lateral branches of the panicle, one to three on each branch. Male flower-heads very numerous, sessile towards the extremities of the lateral branches and termination of the rachis of the panicle. Stigma lanceolate-linear. Fruit *sessile, prismatic turbinate, with a short beak.* Leaves green, broadly linear, not pellucid."

The *Typhaceæ* ("Cats-tails") are true bog or marsh-dwelling rush-like plants, and this genus is met with in almost every part of the world, including the British Islands.

From the fact that the only other vegetable remains observed in these coal-shales are linear leaves which answer to the description of, and might very well have belonged to *Sparganium* (a truly aquatic genus of plants) ; and further, that the only animal organisms observed in these shales are hosts of freshwater snails (*Melaniæ*) and a few scattered fish-teeth,[1] we may venture to conclude, both on direct and collateral evidence, that the reference of our fossil to the fruit of this genus is probably correct.

[1] The teeth are referred by Dr. Günther to a Cyprinoid fish of the genus *Hexapsephus.* The dorsal and pectoral spines are referred by him to a *Siluroid* (also a freshwater form), and named *Pseudeutropius Verbeeki* (see Geol. Mag. 1876, p. 440).

EXPLANATION OF PLATE X.

(Figs. 1–3, *Carboniferous*, Highlands, Sumatra.)

FIG. 1. *Spirifera glabra*, Martin, sp. (ventral valve).
" 2. *Productus undatus*, Defrance (ventral valve).
" 3. ——— *semireticulatus*, Martin (ventral valve).
" 4. *Sparganilithes gemmatus*, H. Woodw., fruit of a Rush-like plant, Tertiary Coal-shales, Sumatra.
" 5. *Cardita Sumatrensis*, H. Woodw., Tertiary, Sumatra.
" 6. *Cardita*, sp. (cast of) " "
" 7. *Lucina*, sp. (cast of) " "
" 8. *Dosinia cretacea*, Reeve, Miocene Tertiary ? Island of Nias.
" 9. *Arca Verbeekii*, H. Woodw., " "
" 10. *Meiocardia sub-Cumingii* " "
" 11. *Hemicardium*, Island of Nias.
" 12. *Pecten*, sp. "
" 13. " sp. "
" 14. *Callista*, sp. (cast) "
" 15. *Cytherea* (cast) "
" 16. *Lunulicardium limaforme*, H. Woodw., Island of Nias.
" 17. Spine of *Cidaris*; Padang Highlands, West Coast of Sumatra.

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

II.—On the Occurrence of Freshwater Remains in the Boulder-clay at Bridlington.

By G. W. Lamplugh, Esq.

On this part of the Yorkshire coast, the storms of last winter have often bared parts of the beach, for a time, of their usual covering of sand and shingle, and have thus exposed to observation many interesting features in connexion with the Drift series. Of these, the most instructive point which has come under my notice is the one which forms the immediate subject of the present communication.

In an exposure, on the beach, to the north of Bridlington, I saw freshwater remains, intermingled with and covered by a Boulder-clay. But before proceeding to details, it will perhaps be better to give a brief account of the chief divisions of the glacial beds in the neighbourhood, without a knowledge of which, the reader might find much difficulty in understanding the continual references made, in the sequel, to these divisions.

The base of the series is generally believed to be formed by the "Basement" clay, which Mr. S. V. Wood has shown[1] to be the same as the "Great Chalky Boulder-clay" of the country further south. I pointed out in a former paper,[2] that this clay extended as far north as Bridlington, and there contained the bed of sand with Arctic shells long known as the "Bridlington Crag." Still more recently I have seen the same clay in a very interesting exposure in Filey Bay (north of Flambro' Head), opposite the village of Reighton, and here also it contained streaks of a clean blue clay, with many crushed shells, identical in all respects with similar streaks in the same clay at Bridlington, which are considered as forming part of the "Bridlington Crag."

[1] Quart. Journ. Geol. Soc. vol. xxiv. p. 146.
[2] Geol. Mag. 1878, p. 509; see also Note, p. 573.

Above the "Basement" clay, there sometimes lies a snuff-coloured clay, which is generally beautifully laminated. This clay is absolutely destitute of pebbles, and contains no shells, nor, in fact, any foreign admixture. Its thickness is very variable, but it does not often exceed four or five feet.

In the exposure at Reighton just referred to, I saw patches of this clay occupying the same position with regard to the Boulder-clays as at Bridlington.

One feature of great interest, which I have lately seen in connexion with this clay, is that, in some places, it shows a very well-marked unconformity between its upper and lower parts.

The lower division, which is the thicker, consists of very fine, pure clay, clearly laminated, but twisted and contorted in all directions. Over it lies the upper division, which is more sandy in nature, and is also finely laminated, but lies perfectly even and undisturbed over the edges of the contorted laminæ below. This upper part also occasionally shows clear steep ripple-marks, running E.N.E. by W.S.W., and having their steep sides facing S.S.E., which shows the probable course of the current by which they were formed, to have been from the N.N.W.

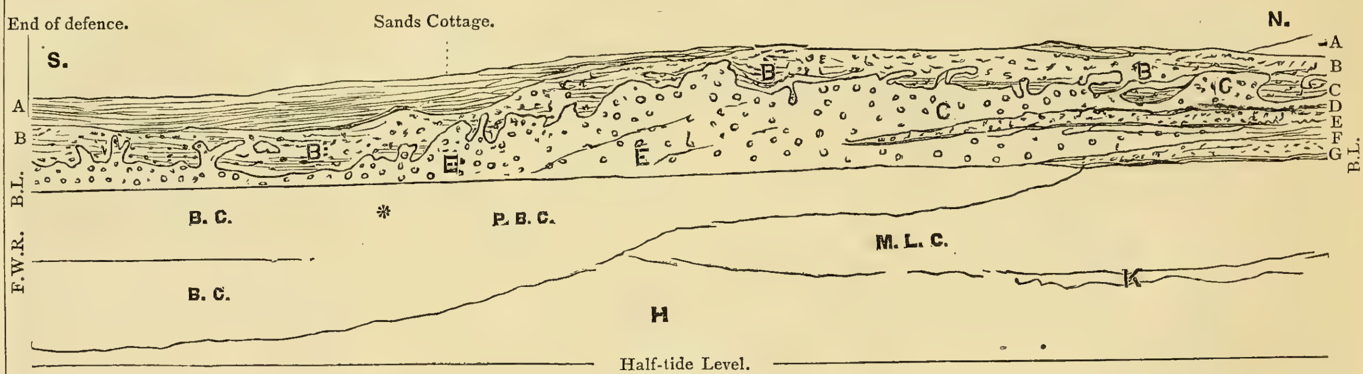
In one or two places a seam of sand comes between this Laminated clay and the overlying Boulder-clay (see Section, F.).

Resting generally on the Middle Laminated clay just described, but where that bed is absent, directly on the "Basement," is another Boulder-clay, known as the "Purple" clay. It contains a few well-worn and rounded shell-fragments. It has, also, numerous intercalated beds of sand and gravel, which contain no shells, and which do not generally continue for any distance. To this, however, there is an exception in the case of the bed D of the section, which may be traced continuously northward for over half a mile, when it is lost to sight amid the slips which there obscure the cliff.

A slight difference is observable between the clay above and below this sand bed. Both the sand, D, and the upper bed of Boulder-clay, C, swell out to a much greater thickness a little further to the north of the section, the sand attaining a thickness of 12 feet, and the clay of nearly 10 feet. It is a matter of conjecture whether this upper band of clay may not be a continuation of the peculiar clay, presently to be referred to as covering the freshwater remains, a point which can hardly be satisfactorily settled, as the sand and gravel bed, D, dies out 70 yards north of the position of the freshwater remains on the beach, and these latter also are only seen in a horizontal exposure, and not in section. But if the band of clay, C, is really separate from the remainder of the Purple clay, it may of course be continued after the sand and gravel bed has thinned out, and resting then directly on the Purple clay; in which case, as the difference between them is only slight, it would be difficult to mark the line of division. There is certainly a difference between the upper and lower portions of the mass of clay, which forms the base of the cliff just under Sands Cottage, the upper part being more stony, and showing irregular streaks of various tints, generally greenish.

Section from the end of the Sea-defence near Sands Cottage to near the cart road up the Cliff, leading to the Lime Kiln: About one mile North of Bridlington Harbour.

Length 190 yards. Average height about 20 feet.



A Recent marls and surface soil.
B Upper glacial gravels thrust into the Boulder-clay beneath; with one or two small patches of Boulder-clay contained in them; not well stratified.
C Upper band of Boulder-clay.

D Sand and gravel, stratified, and sometimes cross-bedded.
E Purple Boulder-clay passing downwards, gradually, into F.
F Sand bed.
G Laminated clay.

The freshwater remains were most plentiful on the beach immediately S. of the section.

* Boulders abundant.

B.L.=Beach-line.
B.C.=Boulder-clay.
P.B.C.=Purple Boulder-clay.
F.W.R.=Freshwater-remains.

M.L.C.=Middle laminated clay.
K.=Very fine earthy gravel.
H.=Basement-clay on beach.

It is in the "Purple" clay that the blocks of Shap granite generally occur. Though they are not often seen on the coast south of Flambro', and have been supposed to be absent,[1] I noticed one lately, about a mile to the south of Bridlington. It was resting on an exposure of the *lower* part of the "Purple" clay. Its dimensions were $1\frac{1}{2}$ by 1 by 1 feet.

Above the top Boulder-clay, in the South Cliff, lie thick beds of laminated warp and sand, mingled with, and passing into, gravel. To the north of the town, these are represented by the gravels, B, of the section. These warps and gravels Mr. Dakyns has recently shown to be glacial.[2] They form the top of the glacial series observable in the cliff sections near Bridlington.

On the beach near Sands Cottage, a small house which stands close to the cliff edge about a mile north of Bridlington Harbour, the sand and shingle have, during the late stormy season, been frequently swept off. On examining one of these exposures, which laid bare a peculiar Boulder-clay, which I supposed at the time to be part of the "Purple" clay, I came across the remnants of the freshwater deposit, consisting of patches of dark silty sand, peaty vegetable matter, streaks of marly clay, passing into clayey sand, often stained black, and containing in places shells, sometimes sparsely, and sometimes in profusion. These shells were all of one species—a variety of *Limnæa peregra.*

These silty sands and clays were closely associated with patches of gravel, generally of chalk, and sometimes ferruginous; a few of these gravel patches, however, contained scarcely any chalk, and appeared to be derived from the washings of a Boulder-clay. The way in which these gravels and the undoubted freshwater remains were intermixed and connected, made it evident that the gravels, also, were of freshwater origin. I noticed in the gravels one or two large foreign blocks.

These patches of gravels, sands and silts were seen to be confusedly mingled with, and, in places, covered by a Boulder-clay, or probably, more correctly, a till, of unusual aspect, the whole together representing the top of the "Purple" clay of Mr. S. V. Wood,[3] which has here, as elsewhere, evidently suffered considerable denudation.

This clay however differed in appearance from the general character of the Purple clay in several respects. It was not of nearly so compact a nature, and where washed by the waves, became very soft and unctuous, almost resembling in this the Middle Laminated clay. It was also not nearly so homogeneous, being full of curious patches of boulders and detritus;—here, the space of a couple of square feet was covered with a mass of small *angular* fragments of black shale;—there, by a similar patch of well-rounded gravel, entirely free from chalk; whilst other patches of gravel consisted almost altogether of chalk. Streaks of variously tinted clays, as if from the grinding of some particular rock alone, were plentifully

[1] Quart. Journ. Geol. Soc. 1870, vol. xxvi. p. 90. [2] Geol. Mag. May, 1879, p. 238.
[3] Quart. Journ. Geol. Soc. 1868, vol. xxiv. p. 149.

dispersed in the clay, with here and there a patch of fine soft clay, entirely free from stones.

The abundance of boulders, of a size much above the average, was another striking feature. I noticed this fact, and the difference in the appearance of the clay, long before I even suspected the presence of freshwater remains. The blocks, a great number of which were from $1\frac{1}{2}$ to 2 ft. long, by about one foot in height and breadth, were chiefly Carboniferous, and were therefore far-travelled. The proportion of blocks from rocks in the district, was surprisingly low; in fact, they were well-nigh absent. Carboniferous Limestone was recognizable by its fossils, also Millstone-grit, Gannister, Basalt, and Carboniferous Sandstone,—the latter being particularly abundant. In one place on the beach, so thickly were these blocks scattered, that, over an extent of nearly sixty square yards, one might step from one to another.

Many of the blocks had their angles wonderfully preserved; and such of them as were of flattened shape, were frequently tilted at high angles or even set on edge in the clay. From the character of the majority of the boulders, but few had retained scratches. I noticed, however, a few examples. One mass of hard chalk 11 in. by 8 in., which showed well-preserved markings, was scored by two distinct sets of scratches; the older ones, running east and west, being crossed at right angles by others, running north and south. This cross-scratching was also observable in many of the instances in which markings were preserved. I could not find that the longer axes of the stones preserved any definite direction, though, in one or two instances, it agreed with the direction of the chief set of scratches; notably, in the case of one large boulder of Mountain Limestone, which was partially buried in the foot of the cliff, and which had a length of 3 feet, by about 2 feet in breadth and height. In this case, the scratchings and longer axis both ran N.W. and S.E.

I have seen the clay showing these peculiarities, exposed on the beach over an extent 160 yards in length, by about 30 in width (see section). To the north, it is bounded by the Middle Laminated clay, as shown in the section, which here rises above the level of high tide, and to the south by the "Basement" clay, on which it in great part rests, the Laminated bed being absent for some distance south of Sands Cottage. The "Basement" clay, therefore, directly underlies, in many places, the clay just described, and cuts it off from the beach when it rises to the cliff-line opposite the Alexandra Hotel.

The Boulder-clay which contained the freshwater remains, contained also a few very small fragments of marine shells of the usual Boulder-clay species; an interesting point, as it is clear that *Limnæa* and *Tellina* could not live in the same place, at the same time. Yet here they occurred on the same horizon of the same bed. There was this difference, however, between their positions; that whereas the freshwater shells were mostly perfect, and were still surrounded by their own proper matrix, the marine shells were in minute fragments, and were scattered through Boulder-clay. The latter have therefore probably been the travellers.

As I was unable to find any trace of the freshwater beds in the cliff-section, it is difficult to make out their true relation to the beds beneath, which were sometimes the lowest part of the Purple (which has been almost altogether denuded away here), and sometimes the "Basement" Clay. It is somewhat curious that just over the extent covered by these remnants, the Middle Laminated clay should be absent; but as it is also absent at other places, this may be merely a coincidence.

The way in which the freshwater beds were tilted and cut up into shreds, separated from each other by thick walls of Boulder-clay, was remarkable. One long strip, containing shells, was five yards long, by only three inches in width, and had gravel on each side. In another case, a small patch of peat, one foot square, was bounded on all sides by Boulder-clay, and was, to all intents and purposes, a boulder itself. These 'shreds and patches' were spread here and there over the whole extent of the peculiar clay just described.

To all appearances, we have here the silt of an old pond, of limited extent, and interglacial in age, through which the ice, on its return, has ploughed, partially destroying it.

As to the exact place of this interglacial period in the series, as seen in the cliff, there is some doubt. It was, at any rate, later than the pause which took place between the formation of the "Basement" and "Purple" clays; and of which the Middle Laminated band is a record. But whether it was formed during a local pause in the Purple clay period itself, or was altogether later, it is a more difficult matter to determine.

It is probable, from the many included sand and gravel beds in the "Purple" clay, that changes of some sort did take place during its formation, but, as far as is known, these sand beds contain no signs of life, either freshwater or marine.

If we allow that it was of later age than the Purple clay, we must also grant that the peculiar clay already described, with which it is mingled, and by which it is in part covered, is not merely the upper part of the Purple clay, but is altogether newer. But the only clay which is known to be newer than the "Purple," is the Hessle clay of Messrs. Wood and Rome,[1] and between it, and the bed under consideration, there are no points of resemblance. The number and size of its sharp-angled blocks; the rarity of chalk fragments; and the distance which most of the boulders must have been carried, make it impossible that this could have been the product of the coast-ice of a limited submergence, which derived its blocks from a pre-existing clay. It is difficult to conceive how anything short of a general Ice-covering could bring distant Carboniferous blocks of such size, and in such abundance. It more nearly resembles the description which Mr. S. V. Wood gives of the upper part of the Purple clay[2] north of Flambro', to which he has given the name of "Purple clay without chalk," and in which he believes the Shap blocks to occur,—bespeaking a wide expanse of ice.

[1] Quart. Journ. Geol. Soc. 1868, vol. xxiv. p. 146. [2] Q. J. G. S. vol. xxvi. p. 90.

As may be partly seen from the section (which shows its northern side only), the freshwater remains occupy the site of an old hollow, which is not even yet quite filled up. This hollow existed even in the "Basement" clay; is continued in the "Purple" clay, and also in the glacial gravels which overlie the Boulder-clay, and which are so strangely, apparently, thrust into it (B. of section); and finally it has been, in recent times, the bed of a pond, which has thrown down the thick bed of marl (A.), partially obliterating the hollow.

This recent marl offers a strongly marked contrast to the ancient bed in the variety of its shells, which are of many species, of *Cyclas*, *Planorbis*, *Limnæa*, *Bithynia*, etc.; whilst the old bed, though so rich in individuals, can count but one species; as though, by some chance, this one shell had, by virtue of its habits, gained a footing, and had increased, undisturbed by any competitors, which at a later period found the same position so favourable to them. I have not seen *Limnæa peregra* in the recent marl.

In conclusion, I may mention the similarity between these freshwater fragments and the so-called "Bridlington Crag," with regard to their relations to the respective Boulder-clays which accompany them. In an exposure of the "Basement" clay, on the beach opposite the terraces which protect the town, which was bared in March last, I saw several separate streaks of a fine, clean, blue clay, and also of a sandy clay, twisted and distorted amidst the Boulder-clay. These streaks contained marine shells of the well-known Bridlington species — *Astarte borealis*, *Tellina balthica*, *Cardita borealis*, *Natica clausa*, etc. Some of these shells were perfect, but more were crushed as they lay, and the fragments more or less separated, as if by the shearing under pressure of their yielding clayey matrix. In a precisely similar manner were the freshwater clays drawn out in their Boulder-clay, with the shells similarly scattered, though not generally so broken.

Thus the movement of the ice at one time over a soft sea-bottom, and, at another, over the silty bed of a pond, has produced precisely similar effects. And the same ice, which cut up the freshwater deposits in this manner, has passed over the sand and laminated clay not 100 yards to the north, and has left scarcely a sign of its passage.

III.—On the Cudgegong Diamond Field, New South Wales.

By Norman Taylor, Esq., of the late Geological Survey of Victoria.

Communicated by R. Etheridge, jun., F.G.S.; of the British Museum.

Since the publication, in the Quarterly Journal of Science for July, 1876, of an article on the Indian Diamond Fields, in which the writer, Captain Burton, does not appear to be aware of what has been done in these Colonies towards adding to our knowledge of the geological history of the diamond, I have been induced to re-write a paper, jointly prepared by the late Professor Alex. M. Thomson, of the Sydney University, and myself, and read before the Royal Society of New South Wales on the 7th December, 1870;[1] and to incorporate with it a series of my own papers (of which the above was merely a summary), which appeared in the "Sydney Morning Herald" previously to that date. I shall confine my remarks to the mode of occurrence of the diamond in New South Wales, as the late Rev. W. B. Clarke has, in his valuable and interesting Presidential Addresses to the Royal Society of New South Wales in 1870 and 1872, almost exhaustively treated the subject, as far as regards our present knowledge of the occurrence of the diamond all over the world.

Professor Liversidge, successor to the late Professor Thomson, of the Sydney University, also read a paper before the Royal Society of N. S. Wales on 1st October, 1873 (reprinted in Mines and Mineral Statistics of N. S. Wales, 1875, p. 104), giving a short description of the Bingera Diamond Field, in the New England District of N. S. Wales, which was discovered some years after its predecessor "the Cudgegong," to which I shall allude further on; as also to my late colleague Mr. C. J. Wilkinson's (now Government Geologist of N. S. Wales) Reports on the discovery of diamonds in the Tin deposits of Borah Creek, a tributary of the Gwydir River, and elsewhere.[2]

Diamonds were accidentally discovered on the Cudgegong river at Warburton or "Two-mile-flat," 19 miles north-west of Mudgee, N. S. Wales, during the gold rush to that locality in 1867. They were scarcely noticed at first, but, at last, several stones were sent to Melbourne jewellers for their opinion, which, ultimately, led to a company being formed to systematically work the deposits. Operations were commenced in July, 1869,—numerous private parties of miners taking up the search at the same time. A large number of diamonds were obtained, although, in most instances, unfortunately, the expense of sinking through considerable thicknesses of solid basalt, the small average size of the stones obtained, cartage to water, and effectual washing, were drawbacks which rendered the search generally unprofitable, and stood in the way of successful investment.

During several months' residence in the district as manager of one of the companies (after the abolition of the Geological Survey of Victoria in 1868), and afterwards as a working miner myself, I made a thorough geological examination of the country, and the results then obtained are embodied in the following description. The plan and sections I had made were unfortunately lost after my departure from the district.

Before describing the nature and contents of the diamond drifts (for they have never been found in these Colonies in any matrix of greater age than our Tertiary drifts), it will be well to give a brief sketch of the geology of the Cudgegong River Basin, and the neighbourhood more immediately surrounding the diamond district. This will assist in any inferences regarding the original sources of the

[1] See Trans. Roy. Soc. N. S. Wales for 1870, pp. 94–106.—R. E., jun.

[2] See Mines and Mineral Statistics of N. S. Wales for 1875, pp. 77–80.—R. E., jun.

various materials which compose the ancient river gravels, as well as of those of more modern origin.

The Cudgegong River rises in the acute angle, open to the west and north-west, which the Great Dividing Range forms in latitude 33° south, and the first part of its course is westerly about 30 miles to Cudgegong village, and north-westerly 37 miles to the junction of the Wialdra or "Reedy Creek." In this part it is bounded on its eastern side by the Dividing Range, which presents a summit of horizontally-bedded Carboniferous rocks, with Coal-seams and *Glossopteris* shales, and from which, farther eastward, rise the heads of the Hunter River, the basin in which most of the celebrated Coal-seams of N. S. Wales occur. The range, in its continuation southwards, completely encircles the heads of the Cudgegong River, and presents a similar formation of Carboniferous rocks, which occur in great force on the upper sources of the river, the Hawkesbury sandstones overlying them. The Carboniferous rocks only reach, along the course of the river, on its north side, westerly to Rylstone. Several outliers and cappings of basalt also occur on summits and spurs of the Dividing Range, as at Mount Bocoble, and elsewhere. The main area of the basin, and the ridges which confine it on the south and west, consist of tilted slate and quartzite, with a few interstratified, and lenticular, bands of fossiliferous limestone. These beds are either of Upper Silurian or Devonian age, but most probably the latter, as the late Professor Thomson discovered the distinctive Devonian genus *Calceola* in the limestone of Mount Frome near Mudgee. Both formations may, however, be represented. These rocks are penetrated in places by small areas of granite, greenstone, quartz-porphyry, and felstone. At the Wialdra Reedy Creek junction, near which the diamond drift first sets in, the river suddenly bends to the south-west and south, and follows that direction to its junction with the Macquarie River, about 28 miles distant. These distances are as the crow flies. This part of its course presents a structure similar to that of the older portions of its upper basin, with the exception that limestone bands are wanting, and no members of the Carboniferous series, except some doubtful outliers to the north-west of the "Two-mile-flat," occur. The whole course of the river is through a rugged mountainous country—the only large flats being situated on and above the diamond field.

Outliers of Carboniferous rocks, consisting of sandstones, conglomerates, and shales containing *Glossopteris* and other plants, form links, at trifling intervals, along the eastern watershed; connecting the Carboniferous formation of the Dividing Range with the Coal-measures of the Tālbrāgār district to the north. A few miles north of the junction of the Reedy Creek with the Cudgegong River, the Carboniferous beds form horizontal cappings on hills of slate and granite, with quartz reefs and limestone bands, as at Tallawang; whilst at Guntawang, to the south, and higher up the river, some doubtful members are met with in the river valley; and near the junction they occur at a similar low level, and have been covered up by the basalt without the intervention of any drifts. The great differences in level, which these latter beds occupy, deserve consideration. For my own part, I believe, with Professor M'Coy of the Melbourne University, to whom the fossil flora were submitted by me, that the Guntawang and Reedy Creek beds, at the lower levels, are Mesozoic. They have only been exposed in comparatively recent times, by the deepening of the river channel, and no remains of them are found in the older drifts. There is no trace of anything like *Glossopteris* in them. For our present purpose it will be enough to show that vast masses of Carboniferous strata have suffered denudation, as, along the main stream, we find relics of these rocks, not only in the present bed, but also in the older drifts, but not in the oldest.

A short distance up the Reedy Creek from its junction with the Cudgegong River, granite appears in the bed, very coarse-grained, with large felspar crystals. Higher up the creek, this is overlaid by basalt, which, a little below the junction of Hapdash Creek, is cut through by the creek, and forms a causeway. At the Hapdash Creek junction the basalt gives place to horizontal ferruginous grits of doubtful age, but probably some portion of the Mesozoic beds occurs lower down.

The deep auriferous "leads" of Gulgong (N.E. of Guntawang), from 80 to 150 feet in depth, are composed of a mixture of angular and partly rounded quartz, in no way resembling the diamond drifts, although both are covered by apparently the same basaltic lava flow. The bottom of these leads is higher than the Diamond leads, and no trace of gems has been discovered in them. Fossil bones have been found in a more recent lead, near the Pipeclay diggings, south of Gulgong, and numerous fossil fruits and plant remains in leads under the basalt at Gulgong, thus indicating their fluviatile origin;[1] whilst neither fauna nor flora (except as imbedded in drifted pebbles, or as particles of ferruginous wood in the conglomerates) have been found in the diamond leads, and I think the latter are undoubtedly of marine or fluvio-marine origin, the circumstances and nature of the drifts having perhaps been unfavourable to the preservation of fossil remains.

The localities on the Cudgegong, which produced the diamond, lie on either bank of the river, extending from the Wialdra or Reedy Creek (18 miles north 30° west from Mudgee) to a point further down, seven miles south-west, known as Hassall's Hill. Along this line the distribution of the diamond is by no means general, but is confined, chiefly, to a few small outliers of an old river drift, which occur at various distances from the present river channel, and at elevations varying from below the river level at the Reedy Creek, to 40 feet more above it further down. This old drift is capped by hard, compact, and, generally, columnar basalt. These outlying hills of diamond-bearing drifts, with their basaltic coverings, though once forming part of a continuous and widespread deposit, have

[1] See C. S. Wilkinson, Annual Report of the Department of Mines, N. S. Wales, for the Year 1876, p. 172; also Baron von Mueller, *ibid*, pp. 178–180.—R. E., jun.

been isolated by extensive denudation. No point of eruption, to my knowledge, exists in the district, but the source of the basalt flow must be to the eastward on the summit of the Great Dividing Range, where it may possibly have been erupted along a line of fault. Its remnants can be followed for, at least, 17 miles down the river, sometimes showing a thickness of over 70 feet, proving the igneous outburst to have been of considerable magnitude, sufficiently so to materially alter the physical aspect of the river valley; we may also infer, conversely, the enormous extent of the subsequent denudation. There is the clearest local evidence that the course of the river has been much altered since the older drift formed a portion of its channel.

Enumerating, in descending order, the outliers of the *older drift* which affords the diamond, the first area occurs near the junction of the Reedy Creek with the Cudgegong River, and a short distance up the former. At this point were situated the works of the Australian Diamond Mines Company, and the village of Reedy Creek. Through the Company's lease a small fringe of basalt runs about north-east and south-west, and under this, near the edge of the flat, and below the present river-level, the most productive diamond drift was discovered. On the hill to the north of the Company's ground is a lead, trending, from the north, southerly, and possibly the bed of the old Reedy Creek, here uniting with the old river-bed. At the south-west end of the basalt fringe, and at the foot of the rise, numerous shafts have been sunk. They were originally worked on a false bottom, at a depth of 29 feet, where the best gold was obtained; but were afterwards worked by the Company on the true bottom at a depth of 35 feet. The basalt was only from 4 to 8 feet thick, and the remainder a similar drift to that at Hassall's Hill (described hereafter), but without the usual fine sand. A short distance to the north-east, near the extremity of this basalt fringe, the sinking was through 30 feet of basalt, and the ground was very wet. The Reedy Creek lead, from 20 to 25 feet in depth, on a dry slate bottom, appears to be higher than the red drift in the above wet ground, the first being the oldest.

The whole of the lead in the Company's ground, though heavily timbered below, settled down, owing to continued wet weather. On the main bottom, in the Company's lease, there occur high hard bars of slate and quartzite, all running in the usual strike of the country. No gold was obtained in the drift between the bars, and the drift itself was semi-angular, and similar to that in the present Reedy Creek bed. At first the ground yielded at the rate of 4 to 5 diamonds and 4 dwts. of gold to the load, but afterwards fell off to one diamond in two loads; and there is no doubt but that numbers of diamonds were thrown out of the machines (Hunt's patent), by careless manipulation, into the tailings, over 1000 tons of which were swept away by the disastrous floods of the 22nd and 23rd April, 1870. While at the works myself, I burned and crushed five bags of cement (which occurs as a bed running in the same direction as the basalt, and in places from 6 to 8 feet thick), and, passing the stuff through a small Hunt's machine, obtained two diamonds and $\frac{3}{4}$ dwt. of gold. The diamonds seemed to have suffered by the burning, as they were quite destitute of lustre. The Reedy Creek deposits contain much larger masses of fossil wood and agate than elsewhere, although the accompanying gems are of the usual size. The total number of diamonds obtained by the Company, while operations lasted, was 1765.

To the east of the village is a long ridge, capped by basalt underlaid by drift, and running nearly due north from the junction back. It is nearly connected, at its north end, by another outlying mass of basalt running easterly. These are merely outliers of the main flow, which is more extensively developed to the east. The basalt of these outliers is higher than that in the Company's lease, and between these two outliers is shallow ground, the top of a sandstone hill, which has split the old river channel. The higher ground is covered by a rounded pebble wash, but on the fall to the back of the diggings, slates and quartz-reefs crop out, evidently a continuation of the rocks on the south side of the river. This basalt hill was worked on its south and east faces, and a pretty rich gold lead was discovered; some diamonds are said to have been found, but were never properly looked for. The sinking varies from 66 to nearly 90 feet. In sinking through the above-mentioned easterly outlier, three-quarters of a mile north of the village, the basalt was found to rest upon fine fissile white and grey shaly beds, full of indistinct plant-remains, and with no intervening drift—in fact, the drift further back appears to rest upon, and not beneath, the basalt, but it is most likely a more recent wash. Some specimens of the above-mentioned plants were forwarded to Professor M'Coy, and pronounced by him to be identical with those of the Cape Patterson Mesozoic Coal-rocks in Victoria. I was unable, at the time, to determine the relations of this bed to the Carboniferous beds of Tallawang, or of either to the green and purple conglomerates west of the Cudgebeyong Creek (described hereafter).

About half a mile above the Reedy Creek junction, and up the river, is a small outcrop of horizontally-bedded alternating grey shales and coarse grits, capped by a conglomerate bed. The shales contain leaf impressions, and the grit traces. The beds form a slight arch, dipping from the centre towards north-west and south-east, but it is probably only a local undulation. They immediately underlie the basalt, which here comes to the river, and forms a bold escarpment, at first on the west side, but afterwards on both sides to within a short distance below Guntawang. Several shafts were sunk on Mr. Rouse's property to the west of the river, and bottomed on horizontal conglomerates; these are again seen at Biraganbil, where they consist of friable grits, with indistinct plant-remains, and hard thick-bedded conglomerates. These beds seem to occupy all the lower country, at the foot of the ranges to the west of the river; the east side is covered up with Tertiary drifts and basalt, and the old river-bed must have been at some distance to the east of its present course. The basalt has flowed from the north-east and north to the river at Guntawang, and then down it; and it is most probable that the drift, in which the diamond occurs, has come from the same direction, although I do not altogether hold with the view that the diamonds have been drifted. All the valleys and lower country (probably synclinal troughs) to the north and west of Mudgee, and elsewhere, appear to be occupied by pebble drifts and beds which may be the equivalents of the above-mentioned Mesozoic rocks.[1]

At the Reedy Creek junction, and south of the river, were situated the works of the Mudgee Gold and Diamond Mining Company. This Company had all their endeavours frustrated by the continuous floods, which destroyed their dams, races, etc., and at last their machinery. Following down the river south-westerly, we pass outcrops of slates, with several large untried quartz-reefs, and near an out-station of Mr. Rouse's, a small fringe of basalt on the rising ground bounding the flat on the south side of the river. Another small basalt rise is met with on the north side of the river, which has here extensive alluvial flats on both sides. A shaft on this hill passed through 25 feet of basalt, and 15 feet of sand, drift and boulders. A little gold and two small diamonds were obtained, but the influx of water stopped further operations. Rounding a rocky point at a mile and a half, the flats go to the north side of the river, while slates and sandstones abut on its south side. The higher ranges to the north contain numerous untried quartz-reefs. Thence the river turns north-west for half a mile, with a large flat on the south side, the surface strewn with angular quartz from the neighbouring hills, concealing the older river drift beneath it, which has been exposed in a few holes sunk. Passing Cunningham's Farm, and going south-west over country composed of shales and brown fissile arenaceous sandstones, a mile brings us to the Puggoon Creek, coming in from the north. Jordan's Flat now lies on the south side of the river, which is here crossed by some "bars" of a very calcareous grit. In the centre of the flat, and resting partly against the flank of the range to the east, is a hill (Jordan's Hill) of the older diamond drift, capped by basalt. This hill is in the form of a triangle; two sides bearing nearly north-east and north-west, and the third nearly east and west facing the river. From the north-west angle a spur runs south at a lower level, also facing the river. The principal sinking has been along the west side of this spur, for a short distance from the basalt, and between it and a high slate bar, outside which are the more recent river drifts. Some shafts have been sunk through the basalt; here about 25 feet thick, and beau-

[1] In the Annual Report of the Department of Mines, New South Wales, 1876, page 173, Mr. Wilkinson, the Government Geologist, states, "The Coal-measures are seen again at the junction of Reedy Creek with the Cudgegong River; they extend into the Guntawang Paddocks, and then in a narrow belt as far as Beau Desert, where, in a well sunk near Mr. George Rouse's residence, the shales show markings of coal." As a much older geologist than Mr. Wilkinson, and having had a longer acquaintance with the district referred to, I cannot help stating that Mr. Wilkinson must be in error in placing these rocks on the same horizon as the true Coal-measures, for the reasons given above.

tifully columnar in six-sided vertical prisms. The columns decompose and break up into concretionary spheroidal masses. Where this spur joins the more elevated mass of basalt, there is a shaft through 12 feet of rubbly and decomposed basalt, full of veins of kaolin, resting on brown and red sandstones with no intervening drift; and it is doubtful whether the lower and higher basalts are connected at all. A shaft was sunk at the north-west angle of the hill through 16 feet of loose rubbly basalt, 42 feet of dense hard basalt, and 18 feet of drift, mostly sandy and similar to the Hassall's Hill drift spoken of further on. A drive was put in on the bottom 60 feet south, where a high bar was met with, and beyond this again was another channel or gutter. The "wash" was very heavy, containing large blocks of "floating reef" and coarse gold. The top of the shaft is about 95 feet above the river, while the top of the hill is 108 feet. From the western angle of the hill, round to the north-east, is a flat fringe of basalt, between the edge of which and the escarpment of the higher main mass, some sinking has been done, but, curiously enough, without going through basalt. This can only be explained by a slip having taken place, which has projected the basalt over and beyond the drift. No drift appears to be present under any part of the hill except the north-west angle, where the lead must run from a little north of east to south of west. The basalt is slightly vesicular, the cavities being occasionally filled with aragonite, and an agatiform carbonate of lime and iron (sphærosiderite), and the joint cracks are much coated with hyalite or volcanic glass. The underlying drift is a good deal cemented, and contains much silicified wood. This hill, by repeated barometrical observations, appeared to be from 30 to 40 feet higher than any of the other outliers, and from this fact, and the presence of hyalite, I at first imagined it might be a point of eruption, the absence of the usual scoriæ and ashes being accounted for by the immense denudation which had taken place, and which had swept away all the lighter material, and left nothing but the denser basalt below. At the spot where the drift from this hill, in the old gold-working times, was washed at the river, the manager of one of the companies obtained, with a Hunt's diamond-saving machine, twenty-one diamonds; and a Mrs. Alexander, with her children, had previously obtained about the same number. A large waterhole, running in the strike of the rocks and half a mile long, bounds the west side of Jordan's Flat, and, at its south end, the flagstones abut on the river at Stony Creek. Here there has been a small lead traced, but the sinking was very wet, as the bottom was below the present river-level; a little gold was obtained, but no diamonds. A striking object is the large quantity of flat boulders of brown and greenish grey grits and sandstones with pebbles of quartz, felstone, porphyry, and greenstone, the latter evidently derived from that at Gulgong, and containing large crystals of hornblende. This deposit seems to be the remains of a former old drift, which has been denuded down, and mixed with the recent river wash, and may probably have occupied the same spot, or nearly so, that it does now.

It may be the surface outcrop of the Gulgong deep leads. The river now trends to the south, through large alluvial flats (unworked) intersected by numerous backwaters or old channels. Turning westerly we pass a red rocky bank composed of grey calcareous grits containing minute *Crinoid stems* (Upper Silurian ?). Some of the grits are much indurated, and the red colour of the rise is due to the contained lime. The river-bed has rocky bars crossing it, where the main range has been cut through, composed of fine-grained grey grits, flinty shales, and thin-bedded red sandstone—all vertical. To the left is the northern extremity of the "scrub lead," which has here run to surface. At the head of a gully are two parallel quartz-reefs in finely micaceous red sandstone. On the right of the river is a low bank showing occasional outcrops of vertical coarse yellow sandstones and grits, covered by an old shallow river wash. A large open alluvial valley joins the river from the north, having at its head, three-quarters of a mile up, a small deposit of river drift, in which a few shafts have been sunk, some having bottomed on greenstone, which crops out at the foot of the ranges. The river-bed is much contracted by the proximity of the ranges, which touch it on the north side. Some workings have been carried on in the ordinary river drift along the south bank.

We now leave the river, and, following the road southerly, pass the "scrub lead" on the left, and Miller's Claim on the right. This claim is 25 feet above the river-level, and has yielded a good many diamonds. It differs altogether from the other leads, with the exception perhaps of part of Buckley's (see on), and is evidently newer than the drift underlying the basalt, from the fact of its lower level, and its containing pebbles of basalt derived from the waste of the protective basaltic covering of the *older drift.* The peculiarity, in this claim, of the bed which contains the gem-stones, may possibly arise from the decomposition of boulders of greenstone and basalt, the former being the bottom rock, which has produced a pure white clay, apparently a hydrous silicate of alumina, etc. It adheres strongly to the tongue, and contains small quartz pebbles, rounded pieces of basalt, blue sapphire, ruby, black pleonast in great profusion, and some wood tin. It is also veined throughout with some bluish opaline mineral (probably phosphate of iron). This bed varies from one to four feet in thickness; and between it and the bottom there are two feet of red sandy drift. A newer river wash, containing pebbles of Carboniferous conglomerates, and mixed with the former, rests on this bed. This, with the alluvial covering, is about 12 feet thick. The diamonds in this drift may have been washed out of an older once-existing deposit, as the unusual accumulation of greensand, at this spot, renders probable. The "scrub lead" is apparently a mixture of recent river wash with the older denuded leads.

We next come to Buckley's hill and lead. Shafts were sunk here in the newer drift at depths varying from forty-three to sixty-five feet. The wash dirt was exactly similar to that at Miller's, but gem-stones were not so plentiful. A few diamonds were obtained, but not sufficient to pay. Like Miller's, this part of the lead rests upon, or near to, a greenstone dyke, and the drift contains large boulders of that rock. The lead passes along the east and south sides of a basalt hill, but the older lead, from which this is a wash, must underlie the columnar basalt, and has not been tried. The south-west side of the small basalt hill is shallow ground. Scattered shafts on the east side of the large flat, forming the "Two-mile-flat," and flanking the western foot of a high sandstone range, running in the strike of the rocks (N. 25° W.), indicate the position of the "Deep Lead." The basalt is here very little above the level of the flat, and is mostly obscured by a wash of clay from the ranges. At Fitzpatrick's Claim, 80 feet of basalt rests on 30 feet of drift, which was worked for gold alone, and gave good results. The bottom is a soft decomposed argillaceous rock, with no visible dip or strike. The gold was contained in a brown loosely cemented brecciated conglomerate of quartz pebbles, sand, and "floating reef" (yellow concretionary sandstone). The adjoining claim (Toby's) yielded a few diamonds, all of good size, nine weighing 23 carat grains. On no other portion of this lead were they looked for. The lead runs round the head of the flat, about 2½ miles south of the village of Warburton, crosses it, and then turns northerly again to the river, which it joins a mile north of the village. The "Two-mile-flat"—19 miles from Mudgee—is about one mile wide, by three and a half miles long, and is bounded on the west by a low range running in a north-west direction from the Big Hill, on the Mudgee road, about 500 feet above the flat; from thence the range rises towards the north-west, on the east side of the flat, to an altitude of over 700 feet above it. The general direction of the ranges is determined by the strike of the rocks (N. 25° W.). The dip of the beds is generally vertical, or very rarely at a high east or west angle. The rocks themselves consist of red and yellow, coarse and fine-grained, indurated sandstone; thin white laminated argillaceous shales; finely micaceous red shales and sandstones; pink and brown fine-grained sandstone, banded with purple stripes in concretionary rings and layers; and hard metamorphic schists. All these rocks, with the one exception named, are singularly devoid of mica. Quartz-reefs occur, but are apparently non-auriferous.

The late Professor Thomson shared my opinion that the age of these rocks is Upper Silurian, the only fossils discovered in them *in situ* being the Crinoidal stems before mentioned. A rounded piece of sandstone, containing distinctive Upper Silurian forms, was found in the drift of Buckley's lead, but has probably come from a considerable distance; similar pebbles, inclosing Crinoidal stems, *Orthis*, etc., were found in the brown sandstone ("floating reef") of the newer drifts on the flat—and also the cast of a *Spirifer* and sections of Crinoidal stems in pebbles of hard quartzite.

On the inside flanks of the ranges on both sides of the "flat," there are five small outliers of basalt, overlying the older gold drifts. It was in these drifts, formerly worked for gold, that the diamonds were found. The centre of the "flat" is occupied by a mass of greenstone (diorite), which originally acted as a barrier to the old river, and diverted its course, in an elliptical curve, round "the flat." Subsequently to the formation or deposition of the drift, a lava stream flowed down the river valley, completely filling its bed, and covering the drift; a new river had then to cut its way, during which process the denudation must have been very great, as nearly all the basaltic lava, and the underlying drift, had been swept away, and partially re-deposited, forming the next older drift. This drift is at a much lower level than the older drift, but still above the present river. The total length of the leads round the flat is about four miles. The *older* lead is only *in situ* under the basalt outliers; and, between and outside these, the lead is *newer*. The drift only underlies the basalt on the eastern side of the basalt hills on the west side of the flat, and on the western side of those on the eastern side of the flat.

The drift underlying these outliers was only worked for gold on the bottom, and the diamond vein may still remain overhead, as diamonds were found in the tailings, and also in the "spoil heaps" at the mouths of the shafts. On the west side of the flat, the newer drift is divided, at a depth of about 43 feet, by a high slate bar, the depth on the west side of which is 58 feet, and on the east from 66 to 75 feet; further south it is 40 feet on the bar, from 28 to 34 feet on the west side, and from 70 to 80 feet on the east side. This bar consists of white and grey arenaceous shales, and white mudstones, and runs in the usual strike. The newer drifts are characterized by a flesh-coloured or reddish quartz gravel, which appears to be derived from the Carboniferous conglomerates; and also by "floating reef," consisting of grey, brown or yellow, coarse and fine siliceous and felspathic grits, in flat oval-shaped boulders, occasionally containing Upper Silurian fossils, olive shales, and fine, flaky, soft white sand rock. The "deep lead" seems to be peculiar to the "flat," and is a series of rather sharp undulations, with occasional flat and sometimes pot-holed spaces. The lead has been very imperfectly traced, for the miners have sunk their shafts in straight lines from one basalt hill to the next, in a way it would be extremely unlikely a river would flow. The bottom of the *older* lead is from 30 to 40 feet above the present river-bed level; and, at a short distance from the river at both ends, the lead has been completely washed away by the river in cutting down to its present level. The contents of these "leads," as would naturally be expected, are very different; the *older* being destitute of local rocks, whilst the *newer* contains remains of the latter, and of the basalt which caps the *older*. The basalt is very dense, hard, and black in its upper part, and sometimes incloses grains of olivine; below, it is mostly decomposed, and of a light slate colour, with veins of a white aluminous silicate. It decomposes very rapidly in concretions when exposed to the air. The upper part affords numerous good examples of columnar structure, occurring in long vertical hexagonal prisms from a foot to eighteen inches in diameter. In the joints between the columns, and other horizontal joints, a peculiar green mineral occurs, probably a clay coloured by silicate of iron. The basalt is magnetic, with strong polarity in places, and the water channels draining off it contain a fine black magnetic iron sand. The columnar structure above noticed renders shaft sinking in these basalt hills tolerably easy. From the peculiar position, with regard to one another, of these basaltic outliers, and the apparent impossibility of drifts of such varying thickness being part of the same river-bed (I now allude to the *older* drift), I at first supposed that "the flat" had once been a lake, subsequently drained by the river cutting through the greenstone dyke; but, on taking a series of barometrical levels across the flats, in and across the strike of the rocks, with accurate measurements of shafts sunk, etc., this supposition proved erroneous; for the drift-bottom is higher at Buckley's, on the east, than at Driscoll's, on the west side of "the flat" or fall of the river, although Buckley's has suffered more from denudation, and is consequently lower than the other hills. During the formation of the *newer* drift it may, however, have been temporarily a lake. The "Deep lead" is a curious feature, for, at Fitzpatrick's Claim, the *older* drift-bottom is nearly 20 feet below what it should be in the average fall of the river, and is nearly on a level with the *newer* drift, and a very little above the present river-level. It is evidently *older* drift, inasmuch as it underlies the basalt,—and the only way to account for it is, that it must have been a large and deep waterhole.

The centre of the north end of the flat is occupied by a mass of greenstone, apparently intrusive. According to the late Professor Thomson, some of the greenstone of the Wellington district is contemporaneous, and interbedded with the Upper Silurian rocks; but, in one place here, we have it cropping out on both sides of a sandstone hill, but not appearing at the top; and, in another place, the greenstone is capped by a mass of altered shales, similar to what occurs at Lancefield in Victoria, where a high greenstone range is capped, in patches, with undenuded outliers of altered flinty shales. Its occurrence in parallel bands, having the same strike as the adjacent vertical and highly-metamorphosed shales, seems to favour the view of its being interbedded, as also does the presence of what may possibly be trappean ash-beds (described further on). I think, however, that, were there any good sections across the strike exposing these rocks, it would be found that the Upper Silurian rocks are here underlaid by a large mass of greenstone, which throws up veins through the joints of the slates and sandstones. The greenstone (diorite) consists of a mixture of hornblende and felspar, and varies from a fine-grained extremely hard and tough compact rock to a coarsely crystalline one. Its colour is a dark green, and in weathering it forms a rich red soil. It exhibits a concretionary structure at the surface, but is very dense below. In places it is largely intersected by epidotic veins of a light chrome green colour, containing, occasionally, rhombic prisms of epidote; it is also characterized by the presence of quartz, sometimes containing confusedly radiating olive-green prisms of actinolite. The felspar crystals have a pale green colour, and a rough parallelism in rings round the concretions. It generally weathers brown, though the more felspathic varieties have the external appearance of granite. It effervesces in joints and minute fissures with hydrochloric acid, and contains traces of a dark brown mica (?). The decomposition of the protoxide of iron in the hornblende, and the partial removal of the lime and magnesia, confer great fertility on the soil derived from the greenstone; and the highest ranges in the neighbourhood which consist of this rock are always clothed with open timber and fine grass, in contradistinction to the Silurian ranges, which are rocky, scrubby, and thickly timbered. To the decomposition of the greenstone is also due the large quantity of magnesite which occurs—in fact, grows—round the waste heaps at the mouths of the shafts. The white clay turned up soon becomes covered with small spherical nodules, which aggregate in time into a solid botryoidal mass of mixed carbonates of lime and magnesia. This only happens superficially, and where the clay has had access to the atmosphere. There seem to be two varieties of this mineral (one of which may be derived from decomposing basalt) as well as a mineral resembling common opal, also showing externally that it is an aggregate of spherical nodules. An analysis of the last, made by the late Professor Thomson, proved it to be a pure hydrated carbonate of magnesia, with specific gravity 2·94, and containing—

Magnesia	46·99	
Carbonic acid	49·78	
Water	4·08	
		100·85

The greenstone possesses two systems of joints,—one striking north and dipping west,—the other striking E. 30° N. and dipping N. 30° W. It was for some time mistaken by the diggers for basalt, and sunk in to some depth. A quartz-vein intersects it, south-west of Buckley's, containing galena, but it had not been opened up.

Along the foot of the range, on the west side of "the flat," is a series of beds, about ten chains wide, having the same strike as the slate rocks. It consists of flinty shales and a thick hard brecciated conglomerate, full of nodules, like amygdaloids, of crystalline limestone, which decompose out on exposed surfaces, and give the rock a vesicular appearance. This breccia also contains fragments of flint, red felspar, etc., in a greenish siliceous base. It shows no bedding planes and passes to the west, by insensible gradations, into a rock of a granitic character, full of felspar crystals, with specks of iron pyrites and galena, and much resembles a felstone porphyry. There seems to be a great similarity between these beds and those in Ireland, described by Jukes as ash-beds. The flinty shales have a peculiar system of joints or false-bedding, at right angles to the strike or real bedding, which latter is seldom distinctly seen. These highly altered shales are characteristic of greenstone intrusions, for they, in every instance, occur as the contact rock, both in New South Wales and Victoria.

The river, at the north end of the "Two-mile-flat," runs westerly across the strike till it reaches the above-mentioned beds, when its course is diverted, and it follows the strike of the rocks for some distance.

Along the top of the range west of the "flat," and crossing the Wellington Road, another greenstone dyke or outcrop occurs, about ten chains wide, and also following the strike in general direction. These dykes, which are all, more or less, of the same character as that already described, run towards the head of "the flat" and beyond it,—the ranges being confusedly intersected with "blows" and outcrops of greenstone, containing quartz-reefs. These reefs may, at some time, prove to be auriferous, like those at Merinda and Gulgong.

A very peculiar isolated conglomerate-capped hill occurs to the north-west of the "Two-mile-flat." The conglomerate, which is about 70 feet thick, and 100 feet above the river, consists of loosely cemented green, yellow, and purple grits with veins of calcite, purple shales, mottled and banded grits, decomposed greenstone, and small and large grained metamorphic breccias from the immediate neighbourhood,—the whole imbedded in a hard, brittle, ferruginous clay, and the large flat boulders and pebbles being all coated with a glistening purple polish. This conglomerate rests unconformably (horizontally) on the tilted Silurian rocks, and is probably of Carboniferous age,—or younger. It bears a considerable resemblance to the rock from Mount Timbertop, in Gippsland (Case x. No. 41, Victorian National Museum Catalogue), and others from the Stony or Moitun Creek, Dargo Road, Gippsland (Case x. No. 17).

The lead, after leaving the Two-mile-flat, crosses the river to its north side, and is there only represented by a thin deposit of newer drift, the basalt and older drift having been entirely denuded away. The gold obtained was not in payable quantity, and the lead was not properly traced.

To the eastward is a schist range, on both sides of which the greenstone dyke, before mentioned, crops out. This dyke apparently splits, or rather underlies and crops out on both sides of, a schist hill near Miller's Claim,—the range, with its accompanying parallel outcrops of greenstone, runs in the strike of the rocks (N. 25° W.) up the east side of the valley of the Sandy or Cudgebeyong Creek.

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

IV.—Notes on the Surface Geology of a Part of the Mississippi Valley.[1]

By W. J. McGee, Esq., etc., etc.,
of Farley, Iowa.

Kames, ˆsar, and minor topographical features.—Kames and åsar are usually found associated. Indeed, the one class of elevations shades into the other so gradually that it is sometimes impossible to draw the line between them. Though the kames may occur singly, they are often in ranges of several, perhaps extending for miles. Each is usually elliptical in outline, and its longer axis corresponds

[1] Concluded from page 361.

in direction with the range. The åsar are frequently intercepted by channels of erosion, by which they are divided into ranges of oblong hills, the direction of which is very nearly the same as that of the kames proper. In Dubuque county, Iowa, where these features have been most thoroughly studied, this direction is about S. 75° E. Within 40 miles south-west from there the direction changes to about S. 45° E., and in the next 50 miles the direction becomes a trifle west of south; and this is the general direction over the greater part of the region examined.

Though generally independent of the present minor lines of drainage, kames, when they occur singly, often bear a distinct relation to neighbouring topographical peculiarities. Thus in Dubuque county, a single kame is often found at the head of a "draw" extending N. 75° W., and communicating with a deeper transverse valley or streamlet. If several such "draws" are parallel, and of about the same length, a series of kames may extend in a direction corresponding with that of the larger valley; but their longer axes correspond with that of the "draw." Again, when a stream flowing to the north or south bends abruptly to the east for a mile or two, and then resumes its course, a prominent kame, which may be of considerable length, may often be found on the upland east of the bend. A fine instance of this character may be seen at Rockville, on the line between Dubuque and Delaware counties, where a kame nearly a mile long lies opposite such a bend in the Maquoketa river. Its altitude exceeds that of all other hills in the vicinity. There is a very small but strikingly characteristic kame near by, directly opposite a steep, rocky ravine on the west side of the river, extending about S. 63° E. The kame is fully 60 feet high, and its base is not more than 200 by 375 feet. Its longer axis extends S. 60° E.

The ridges already spoken of as extending across a part of Dubuque county from west to east, are believed to be true åsar. One, which passes just south of Farley, has been traced over 10 or 12 miles, though there are two or three breaks in this distance. The same ridge, probably, extends many miles further westward; but it is so broken by the two branches of the Maquoketa river and their tributaries that it is difficult to positively establish any connexion between the portions supposed to be related. This difficulty is enhanced by the sandy and friable nature of much of the soil west of the easterly branch of the Maquoketa. Similar elevations have but seldom been observed in other localities; though some formations, believed to be analogous, were recently noticed in the vicinity of Aurora, Illinois. Circumstances prevented their thorough examination.

Both kames and åsar are chiefly composed of members one and two in their proper relative positions, number two being much thickened, and generally stratified, assorted, and laminated. Geikie's description of the kames of Scotland[1] will often apply word for word to those of this region, except that here they are

[1] "Great Ice Age," chapters xvi. and xvii.

capped, in the large majority of cases, by the löss-like member. The rather hurried examination given to those of the level plains of Illinois failed to reveal any order or system in their distribution. They begin to appear at intervals about 40 or 50 miles north of the southern limit of the unmodified upper drift (number three), and dot the surface to the southward, increasing gradually in extent and number, but finally diminishing in altitude, and at last becoming merged in the löss there forming the uppermost deposit. These elevations have in some cases been found to be wholly independent of the subjacent members; and it is suspected that, where they are not coördinated with the configuration of the basalt rocks, they are always so.

Terraces are rare, and never prominent. There are none which, in the judgment of the writer, owe their origin to continental oscillations in level, or even to a gradual elevation of the land. The two principal surface deposits, too, are spread over the older rocks uniformly, on hills and in valleys alike, independently of altitude.

Roches moutonnées occur in many localities, but their materials are usually too friable, and their surfaces too greatly weathered, to exhibit striæ. Ground and polished rock-surfaces, which are so often seen in broken and hilly countries, are almost unknown here; but it must be remembered that extensive surfaces are very seldom exposed, being ordinarily deeply covered with drift. Neither have the "striated pavements" of Hugh Miller been observed.

Sections.

To the working geologist a few actual sections will be of as great value as the more general description. The following are taken almost at random from the writer's notes.[1]

The relations of some of the members could only be clearly exhibited by means of sketch sections; and hence no effort has been made to select those containing such members. All were observed in wells.

1. *A well at Woolam's Station, Stephenson county, Illinois.*

Soil		2 feet.
Coarse yellow clay, with boulders and chert		18 ,,
Blue clay, clean and unstratified		25 ,,
Gravel and sand, stratified, on rock		5 ,,
Total		50 ,,

2. *Mendota, Illinois.*[2]

Yellow clay, with boulders		12 feet.
Blue clay, sometimes sandy		55 ,,
Gravel	3 inches	
Blue clay, laminated and sandy		7 ,,
Water-bearing gravel reached.		
Total		74 ,,

A sample of the blue clay from 60 feet below the surface contains

[1] In the paper read before the American Association is a table of eighty-three sections in North-eastern Iowa.

[2] Communicated, with the following, and with samples from different depths, by Dr. J. D. Moody.

many small fragments of wood, probably Red Cedar (*Juniperus virginiana*). Boulders were not reported in the yellow clay, but were seen in it in the immediate vicinity by the writer.

3. *Artesian well at Mendota, Illinois.*

Surface soil	2 feet.
Yellow clay, with boulders	12 „
Gravel	2 or 3 inches
Blue clay	75 „
Indurated and shaly blue clay	2 „
Coarse reddish and yellow clay	69 „
Total	160 „

In a third well, at the same place, the layer of ancient peat already mentioned was encountered.

4. *Near Cascade, Iowa.*

Clean light-yellow clay	6 feet.
Pebbly ditto	1 „
Yellow clay, with boulders	13 „
Black sandy loam	1 „
Clean blue clay	26 „
Yellow sand, with boulders and pebbles	2 „
Total	49 „

Wood was found in fragments on the surface, and in the upper portion of the blue clay, in the black loam, and a little in the base of the superincumbent yellow clay. Except for absence of member number six, this is a typical section, and, besides, has the "forest bed" *in situ.*

5. *Near Epworth, Iowa.*

Surface soil	1 feet.
Sandy yellow clay, with boulders	10 „
Clear blue clay, with small pebbles	14 „
Clear, fine, white sand, laminated	1 „
Coarse gravel, entirely free from clay	1 „
Total	27 „

A sound log of *Juniperus virginiana*, 8 inches thick, extended across the well at 20 feet from the surface, and was cut off at both sides.

6. *In Dakota, Humboldt co., Iowa.*

Black soil	6 feet.
Yellow sandy clay, with boulders and limestone pebbles	20 „
Clean blue clay	16 „
Coarse gravel and sand, with water	1 „
Total	43 „

A stick (probably cedar) 2 feet long and 4 inches thick was found 30 feet beneath the surface. On reaching the water-bearing gravel, the water rose 20 feet, and has ever since remained at the same level. In a neighbouring well an upright trunk and branches of a tree (probably Willow—*Salix*, sp. und.) were found below the yellow clay.

7. *At Aurora, Illinois.*

Yellow clay, with boulders	16 feet.
Clean blue clay	4 ,,
Clean sand and gravel, stratified	3 ,,
Total	23 ,,

8. *Ten miles N. W. of Dubuque, Iowa.*

Surface soil	2 feet.
Clean, light-yellow clay	12 ,,
Sand and gravel, stratified, with small, much-worn boulders	6 ,,
Loam, not distinguishable from surface	3 ,,
Jointed blue clay, clean	10 ,,
Sand and gravel, with water	1 ,,
Total	34 ,,

9. *Twelve miles S. of Storm Lake, Iowa.*

Yellow clay, with pebbles	10 feet.
Clean, unstratified, blue clay, very hard when dry, but plastic when wet	8 ,,
Sandy red clay, with rounded pebbles	17 ,,
Total	35 ,,

10. *Near Ida, Ida county, Iowa.*

"Bluff deposit"	15 feet.
Nearly pure yellow sand	10 ,,
Clean blue clay, with roots and branches	5 ,,
Sandy blue clay	4 ,,
Yellow sand, with a little clay, and a small boulder or two	14 ,,
Coarse gravel, with boulders	4 ,,
Total	52 ,,

11. *Wyoming, Jones county, Iowa.*

Coarse yellow clay, with boulders, pebbles and gravel, slightly stratified	20 feet.
Blue clay, with occasional intercalated layers of fine gravel and sand	20 ,,
Sandy yellow clay, with pebbles	1 ,,
Total	41 ,,

12. *Near Red Oak, Montgomery county, Iowa.*

Black soil	2 feet.
Yellow clay, gravelly and sandy	28 ,,
Blue clay, with boulders and fragments of wood	4 ,,
Very hard and clean yellow clay	20 ,,
Yellow clay, with gravel	4 ,,
Sand	1 ,,
Yellow clay, with gravel	4 ,,
Sand, with water	1 ,,
Total	64 ,,

This section seems anomalous, but it is probable that only members three, four, and five, are represented. Four and five may constitute a buried kame. This well was excavated in the highest hill in the neighbourhood.

Interpretation of the Record.

Without the least disposition to discuss mooted points, especially as regards the relative efficiency of land-ice and floating bergs in laying down finely comminuted and coarser materials without arrangement, the writer may briefly summarize the conclusions to which he has been led by the study of the surface deposits of the regions described.

Member number six is believed to be the product of a continental glacier because (1) it contains pebbles of the Archæan rocks, which must have been brought from a distance of from 200 to 400 miles, mixed with a larger proportion of local ones; and because (2) it occurs at various levels, and is unstratified. It is believed to be distinct from, and much older than the incumbent members, because its materials have undergone much more secular modification; and by far the greater part of this took place before the advent of the succeeding glacier. The cementing of a part of its materials into pudding-stone occurred previous to any subsequent cataclysm, as is attested by the finding of this pudding-stone in all of the more recent formations. Even its erratic lumps of clay are easily distinguishable from their surrounding materials, and their true relations readily traced.

Members number four and five also contain northern rocks, often striated, and occur at all levels; and their materials are often confusedly intermingled. Lumps of the blue clay occur also in member number three; and in North-eastern Iowa the boulders of these members are of a different character from those of the next. They are therefore considered to be of glacial origin also, and to be distinct from and much older than the overlying deposits. In addition to the evidence above detailed, we have every reason to believe that the accumulation of a great mass of vegetation, and the development of a characteristic fauna,[1] took place subsequently to the laying down of these members and previous to the coming of the latest glacier. Only during an immense period could this have been accomplished.

For reasons which every geologist will recognize in reading its description (even if he does not admit their adequacy), member number three is believed to be of glacial origin. It is so considered, indeed, by most of the various State and other geologists who have examined and described it. The reasons for considering it to be distinct from and much newer than the lower till, need not be rehearsed.

Partly in consequence of a high estimation of the opinions of many eminent men, member number one is provisionally assumed to be due to sedimentation in local basins formed at or about the close of the last glacial epoch; and member number two is thought to be the coarser materials left when the lighter portion was carried away to form the löss-like clay. As previously intimated, there is reason for believing that a part, at least, of this assortment took

[1] Some references are given in the paper already mentioned, which bear upon this point.

place before the final retreat of the ice. It may be mentioned in passing that some careful observations recently made in a neighbouring State point to a yet more sweeping conclusion. During last season, Prof. N. H. Winchell, the State Geologist of Minnesota, found that the unmodified glacial drift of that State graduates bodily into the löss of the Missouri Valley.[1]

As intimated at the outset, the general conclusion reached by the writer is that three different glacial epochs have succeeded each other at long intervals; and from analogy with the present, as well as from direct evidence, that a characteristic fauna and flora spread over the land during each of these intervals, whose counterparts are to be sought for in the more recent marine formations. Though purely hypothetical, and warranted only by the known uniformity of the natural processes, and the apparent inadequacy of catastrophic agencies,[2] it may also be suggested that earlier glacial eras have probably occurred at long intervals, as argued by Dr. Croll, and that these cataclysms may have inaugurated the disturbances separating the successive geological eons.

It would seem, however, to be palpably unjust to the talented author of "Climate and Time," and to the able geologists who have fallen in with his conclusions, to reject the hypothesis of *inter-glacial periods,* in the sense in which the term is used by the Scottish geologists, without offering any reason therefor. Hence, if the introduction of arguments not strictly geological may be permitted, the chief reasons for not adopting that view may be briefly outlined.

Premising that it may be laid down as an axiom that inter-glacial eras of mild climate could only exist when the whole of the ice of the preceding epoch had been removed from the Polar regions, the leading objections to the assumption of such eras may be summed up in two propositions. *First,* it would probably require all, or nearly all, of such an era to melt the ice accumulated around the pole; and *second,* it would probably require a much longer period to effect the fertilization of the morainic debris, and the introduction and acclimatization of a luxuriant flora, such as that represented in the North American forest bed.

In discussing the first proposition, the leading principles of the ingenious theory explaining secular variations in climate, which was first developed and elaborated by Dr. Croll, will be adopted.

For our present purpose it may be assumed that the melting of ice and the elevation of the earth's temperature is due to solar heat alone; and both stellar and proper terrestrial heat may be disregarded. The amount of solar heat reaching the earth's surface is known; and the proportion cut off by the earth's atmosphere has been determined by Pouillet and others. The amount reaching the outer surface of the terrestrial atmosphere is thus known also. It is sufficient, as we are told by Dr. Tyndall,[3] to melt a layer of ice 100

[1] "Ann. Rep. Nat. Hist. Surv. of Minn.," 1878. See also Ann. Journ. Sci., Feb. 1879, p. 168.

[2] *Vide* "Cataclysmic Theories of Geological Climate," Croll—in Geol. Mag. for Sept. 1878.

[3] "Heat as a Mode of Motion," Amer. ed., par. 684.

feet thick over the whole surface of the earth, provided it were all employed in that direction and were uniformly distributed. But the heat received by the frigid zones annually, per square foot, is less than the mean received by the whole earth in the ratio of 5·45 to 9·83, according to Meech.[1] Therefore only 55·44 feet would be melted from the frigid zones in a year, if all the solar heat reaching them were utilized for that purpose. But Prof. Tyndall tells us in the same paragraph that four-tenths of the solar heat is absorbed by the terrestrial atmosphere, on an average. Now it is universally conceded that the atmospheric absorption is greater in polar than tropical regions; but to be sure of erring on the safe side, if at all, the mean mentioned by Tyndall may be taken as representing the atmospheric absorption of the frigid zones. Radiation and direct reflection from snow-covered regions may also be disregarded, though important factors. Diminishing, therefore, the solar power in arctic regions by four-tenths, we find that only 33·26 feet of ice could be melted annually from the frigid zones, if all the heat were so employed.

But normally all the solar heat is expended in raising the temperature of the earth's surface to a certain point, which is too low to remove all of the ice from polar regions. To keep the temperature as at present, and at the same time remove 33·26 feet of ice from the frigid zones, the solar action would have to be doubled; and, similarly, to remove any less quantity of ice, the heat would have to be proportionally increased. The same effect could be produced, however, by lengthening the summer and shortening the winter. The whole amount of heat reaching the earth, or any part of it, may be conveniently represented as 365 days. Each hemisphere may receive 365 days of heat; but, owing to telluric changes, the amount received by one may be augmented, and that received by the other diminished. This is argued by Dr. Croll, who, while admitting that a lengthening of summer is exactly counterbalanced by the greater relative distance from the sun, insists that a chain of physical agencies is brought into operation, by which the heat actually rendered effective is made to about equal, proportionally, the lengthening of the summer. It would be absurd to consider it more; and in truth it is probably less; but it may be assumed that it is proportional. During the last period of great excentricity in the terrestrial orbit, which occurred about 210,000 years ago, there was a time, according to Croll, when the northern summer was nearly 27 days longer than its winter; and it may be admitted that the whole northern hemisphere received 27 days more heat than the southern, or 13·5 days more than the normal. This is the maximum for a period of about 12,000 years, and the two minima are each zero, when the distribution of heat over the two hemispheres is equal, as it is when the apsides coincide with the equinoxes. The mean excess for the period of say 12,000 years would thus be only 6·75 days, or $\frac{6 \cdot 75}{365}$ of the total accession annually.

[1] "Relative Intensity of the Sun's Light and Heat," Smithsonian Contributions to Knowledge, 1855, p. 35.

The temperature being supposed to remain the same as at present, during each year $\frac{6\cdot 75}{365}$ of 33·26 feet of ice, or ·615 foot, would be melted annually. At the same rate there would be melted in 12,000 years, 7,380 feet, or 1·4 miles. Though we do not know how much ice was actually melted from the frigid zone at the close of the glacial period, or within any inter-glacial era, it may be mentioned that, in calculating the continental submergence supposed to have been brought about by the last glacier, Dr. Croll estimates that at least two miles of ice were removed from the southern hemisphere.[1] The inadequacy of the inter-glacial periods to accomplish this is obvious in view of the above calculation.

Regarding the second proposition but little need be said, though the subject is a broad one, and worthy of the study of a Hooker or a Darwin. We know that crude soils, such as fresh glacial clays from some yards beneath the surface, are not adapted to the support of a luxuriant vegetation. Thistles, yuccas, cacti, and other hardy plants may spread over barren clays, sterile sands, and tufaceous wastes, and are sometimes planted with the object of reclaiming such areas; but even when other germs are not lacking, it is only after considerable periods that a richer flora supersedes these plant-pioneers.[2] After the retreat of a glacier, however, there would be a dearth of seeds and germs; and their spread over the glaciated wastes would be slow. This is substantiated by the observations of Professor Alphonse de Candolle in the Alps, and of Professor Blytt, of Christiana, in Scandinavia, who find that "of the valleys laid bare at the glacial period, those whose glaciers retreated first present a richer and more varied vegetation than those which remained a long time covered with ice."[3] Dr. Hayden also observed an analogous phenomenon during the season of 1877. The western slope of the Wind River Mountains exhibits abundant traces of glaciation evidently quite recent, geologically speaking, though it may well be doubted whether the glaciers have existed within many centuries; yet "scarcely any vegetation has sprung up on the light glacial soil."[4]

While freely admitting that any conclusions, drawn from so imperfect a record as that afforded by our surface deposits, and from ulterior speculations, must be only provisional and of little weight, the writer feels justified, in view of the foregoing considerations, in rejecting the hypothesis of inter-glacial vegetation. He may be permitted, however, to express the high estimation in which he is inclined to hold the general principles of Dr. Croll's most ingenious and plausible theory.

[1] "Climate and Time," Am. ed., pp. 377 and 388. For difference in amount of heat received by the two hemispheres, see *ibid.*, table iv. p. 320.

[2] The well-known fact that the productiveness of soils and the richness and variety of the flora they support, is directly proportional (other things being equal) to the amount of humus in the soil, is strongly emphasized by the analyses given in the annual report of the Wisconsin Geological Survey for 1878, which has just been received.

[3] "Report on the Transactions of the Geneva Society of Physics and Natural History," by Dr. J. Müller, translated for "Smithsonian Report," 1877, p. 221.

[4] *Résumé* for 1877 in Smith. Rep. 1877, p. 58.

REVIEWS.

I.—Etudes Synthétiques de Géologie expérimentale. Première partie. Application de la méthode expérimentale à l'étude de divers phénomènes géologiques. Par A. Daubrée. 8vo. (Paris, 1879.)

IT has been objected to geology as a science that its conclusions were frequently based upon insufficient premises, and that it was lacking in actual demonstration. Indeed a writer of eminence once described geologists as a set of persons who amused themselves by constructing worlds and then pulling them to pieces again; and it must be confessed that the reckless guesses of an imagination not always scientific, which have at times obtained a temporary notoriety, did in some cases justify the charge. Still it should be remembered, as Mons. Daubrée points out, that the study of the Earth, after having been for a long time hypothetical, did really, towards the end of the last century, enter "une voie positive," where it has taken for its guide the observation of facts.

Exactly a century has elapsed since the first appearance of de Saussure's works on the Alps. Werner and Hutton followed shortly, and the endless dissertations of their respective disciples may perhaps have had something to do with the strictures previously mentioned, especially as they took root in those soils where discussion on subjects more or less transcendental seems to be an indigenous plant. Yet, even in the earliest years of the present century, the importance to the geologist of the synthesis of minerals was recognized, although it was at one time considered that the divergence between certain minerals and the most analogous compounds which the laboratory could furnish was such as to render their actual reproduction impossible. The difference between crystalline quartz and the amorphous silica of the chemist was almost as great as that between the diamond and the soot of our chimneys. To effect such marvels, lapse of time and certain occult actions were deemed necessary, or, as Leibnitz put it in the *Protogæa*, "il faut du temps, du repos, et de l'espace."

In 1805 Hall experimented with a view to control some of Hutton's views, and succeeded in making chalk semi-crystalline under the influence of heat and pressure, whilst Haussmann, a few years after, turned to account in the interpretation of geological phenomena the examination of the silicates of the metallurgical furnaces.

The year 1823 marks a discovery of the utmost importance. Mitscherlich recognized that péridot, pyroxene, and other mineral species crystallized in slags, and Berthier, by melting silica with different bases in definite proportions, actually obtained crystalline combinations identical with those of Nature, especially pyroxene. It was the first step made in the direct synthesis of minerals.

The next step was to overcome the difficulty presented by insoluble combinations in the wet way, and Haidinger, being desirous of controlling Von Buch's hypothesis, inaugurated the employment of water under pressure in the formation of dolomite, whilst the numerous minerals accumulated in metalliferous lodes, which observation had shown could not have been conveyed either in a state of volatilization or of fusion, attracted attention with a view to their reproduction in the wet way—no easy task, when it was seen that silica itself in separating from water assumes the condition of opal rather than of quartz. This void in synthetic mineralogy Sénarmont filled by the employment of appropriate substances, such as are most widely distributed in existing thermal springs, operating at temperatures above 100° C., and under pressure. In this way he succeeded in the formation of quartz crystals, small, it is true, but possessed of the physical and optical as well as the chemical properties of natural quartz. Since then another triumph of synthesis has been scored by Hautefeuille in the artificial production of orthose and albite.

Such is a brief outline of the very useful historical sketch which Mons. Daubrée gives as a prelude to the results of his own researches, which, after being continued for 40 years, and scattered through many publications, are now comprised in one volume. This will enable the reader more fully to estimate the value of his labours, and at the same time will materially assist the geologist who has not carried on similar work. The bearings of experimental geology may assist in explaining many of the chemical, physical, and mechanical phenomena which he meets with in the field, and the causes of which are difficult to understand, considering the complex subsequent modifications which have too frequently masked their primal origin.

The first section of the volume deals with *chemical and physical phenomena* in three chapters; wherein the author shows the application of the experimental method, 1st, to the history of metalliferous deposits, 2nd, to the study of metamorphic and eruptive rocks, 3rd, to the history of volcanic phenomena. A portion of the second section, where the author describes the chemical decomposition of silicates, such as felspar, by mechanical causes, in part belongs to the subjects discussed in the first section.

The history of metalliferous deposits is divided into (1) stanniferous masses, (2) "gites sulfurés," commonly called plumbiferous, (3) "gites de platine."

In dealing with the *Stanniferous* group M. Daubrée can point out how accurately he described in the "Annales des Mines," nearly forty years ago, the origin and constitution of tin deposits. The peculiarities of this group—so different from the other, in which the electro negative is mainly sulphur—are noted; the mineral occurs as an oxide, and the gangues are not the same. The metalliferous fissures, too, are not like ordinary lodes in the proper sense of the term, but seem to be more like a number of small shrinkage cracks, and the neighbouring rock is charged for some distance with the mineral (cassiterite). This network of small veins contains an enormous proportion of quartz, and the oxide of tin is further escorted by certain minerals unusual in ordinary lodes,—such as topaz, pycnite, tourmaline (schorl), axinite, and also apatite,—so that the accompanying elements, besides silicon, are boron and fluorine, and frequently phosphorus and arsenic, forming combinations which cannot be explained by the mere chemical analogies of these different elements, as is the natural association of iron with manganese, or cobalt with nickel. These observations have been supplemented in a recent contribution to the Quart. Journ. Geol. Soc. by Dr. Le Neve Foster, who gives some very interesting details, especially as to the fact of lodes, containing from one to three per cent. of cassiterite, themselves consisting of schorl rock, which he describes as a matted mass of fine needles of schorl in a ground mass of quartz, with granules of cassiterite scattered through it, or arranged in little strings and veins. From these considerations it may be gathered that fluorine was the agent which performed at once the part of carrier and of mineralizer, thus discharging the task allotted to sulphur in the plumbiferous (sulphuretted) group.

Fluoride of tin is a compound stable at high temperatures, and in all probability the tin came up as fluoride from the general reservoir of the heavy metals. Boron too has a tendency to combine with fluorine, and fluoride of boron being volatile would also ascend. In the artificial preparation of cassiterite, effected by M. Daubrée as long ago as 1841, not having conveniences for the employment of fluorides, he brought together in a porcelain tube the vapour of bichloride of tin and steam at a temperature below 300° C. Small but well-formed crystals resulted, having a density of 6·72, and adhering closely to the sides of the tube. Similarly, by employing perchloride of titanium, he obtained small crystalline grains of titanic acid. The artificial production of apatite was effected by the action of perchloride of phosphorus, first on caustic lime and afterwards on chalk, the result being a true chlor-apatite. In these operations some chloride of silicon was formed at the expense of the porcelain. Thus he argues, that if the vapours of stannic chloride and fluoride, which appear to have formed the stanniferous deposits, were accompanied by perchloride of phosphorus, this latter, when encountering lime in the enveloping rocks, must have formed apatite accompanied by fluor spar.

Still referring to this subject, M. Daubrée, whilst apologizing for introducing his own work as that of a geologist rather than of a chemist, mentions that, seventeen years after these experiments (viz. in 1850), Deville produced corundum by means of volatile metallic fluorides re-acting on oxidized compounds, and that by means of fluoride of titanium Hautefeuille reproduced the three forms of titanic acid.

The *sulphuretted* group, being the one in which the majority of metals occur, is not dealt with generally, but M. Daubrée points out the existence of analogous products of recent formation in warm springs, such as those of Bourbonne-les-Bains. An abstract of the author's paper in the "Comptes Rendus" for 1875 has already appeared in this MAGAZINE. Bourbonne-les-Bains is not the only place where Roman coins have yielded metallic sulphides, but there the circumstances seem to have been peculiarly favourable, and

M. Daubrée illustrates these by a series of cuts with much exactitude. Some 20 kilogrammes of bronze coins were found at the bottom of a Roman well (*puisard*), associated with black organic mud, where they had been bathed for sixteen centuries by mineral waters at present containing 8 grammes of solid matter to the litre, and having a temperature of 68° C. at the principal point of discharge. In a permeable bed towards the bottom were evidences of bronze coins, etc., which had undergone decomposition, more or less complete. Four species of cupric sulphide result. The tin appears as a white earthy crust, consisting chiefly of oxide. The lead pipes in places were coated with phosgenite (carbonate of lead and chloride of lead), which, by the reducing action of organic matter in the presence of gypsum, has yielded small but definite crystals of galena.

Such an automatic laboratory, containing within itself a sort of electro-chemical apparatus, was a valuable legacy of the Romanized Gaul to his descendants, not to be appraised so much for its metallic worth, as for its utility in supplementing those essays in synthesis which the shortness of human life too often forbids to be accomplished within the limits assigned to one generation. We also learn in this case how Nature is gradually reversing the operations of man; remarrying, as it were, those elements which had been divorced by the laborious operations of the miner and the smelter.

It is just possible that discoveries such as the preceding, confirming our knowledge of what can be done in the wet way in warm springs and mine-waters within periods short in a geological sense, may tend to exaggerate the importance of the part played by water as a solvent at a time when the great sulphuretted lodes received the bulk of their metallic charge. These phenomena merely represent the final stages of processes infinitely more energetic. M. Daubrée asks, What should we see if it were possible to descend the fractures serving as channels for the ascent of the thermal waters? We should probably find additional proof of the important modifications produced by water at increasing temperatures, but this would not lessen the probability that the metals associated with lead have been volatilized from depths where no water is in combination with sulphur, selenium, tellurium, or arsenic, just as he has shown how tin has been volatilized in combination with fluorine.

The second portion of the chemical and physical subdivision of the subject treats of the *metamorphic and eruptive rocks* and of the application of the experimental method to their study. The author interprets the word 'metamorphism' in its widest and most conventional sense, 1st, as simple molecular re-arrangement, 2nd, as crystalline re-arrangement based on matter already on the spot, 3rd, as crystalline re-arrangement with importation of new or elimination of old matter.

Metamorphism of juxtaposition is the term he prefers for those modifications which are effected by invading rocks within moderate distances, though such modifications may reach as far as 3000 mètres in the case of granitic invasions. In dealing with regional metamorphism he expressly excludes the old gneisses and mica-schists which underlie the stratified fossiliferous terranes, and confines his observations to the schistose masses whose metamorphic origin is, he says, clearly demonstrated.

This is certainly begging a question which many persons would be by no means willing to concede. The above quoted remarks were originally published by M. Daubrée in 1859, and have not been altered in the present work, so that no reference is made to the numerous memoirs which have appeared since that date. It is clear that M. Daubrée still continues a strong believer in the doctrine of Epigenesis—that Hibernian form of metamorphism which is accompanied by considerable change of substance. It somewhat detracts, therefore, from the interest of this part of his work, that he has not thought fit to notice the numerous papers contributed to this subject of late years. We find him, for instance, stating that this modification (regional metamorphism) is easily recognized in such countries as Wales, the Taunus, and the Ardennes. Certainly the alleged metamorphism of portions of the former country has been disputed on good grounds by very competent observers, who, although they probably differ in details, have adduced most excellent evidence that certain beds of obscure origin are by no means the metamorphosed equivalents of beds elsewhere recognized as forming part of sedimentary formations of known age. We leave the Taunus and the Ardennes to the consideration of foreign critics.

In the Alps there seems to be better evidence of metamorphism as understood by M. Daubrée, but the strongest case is the well-known one in the Vosges, where, as observed by M. Delesse, the organic remains so well preserved at Rothau deserve to be considered as the classical monuments of metamorphism. Here syenitic granite has penetrated Devonian beds, which for several hundred mètres from the point of contact are entirely modified. At certain points the altered rock consists of a compound of lamellar pyroxene, epidote, and compact garnet, associated with abundance of fossil corals. The cavities bristle with elongated crystals of amphibole, etc. Such a case as this should in fairness be quoted under the head of metamorphism of juxtaposition; but anyhow it is a hard nut for those who disbelieve in the extensive alteration of sedimentary beds to crack.

The causes of metamorphism are next considered, and here it is again evident that change of substance as well as of form is the kind of metamorphism most frequently present in the mind of the author. Heat (which is from two sources), even when aided by certain vapours, is not sufficient; we must, then, look to water as having performed an important part "dans les phénomènes métamorphiques aussi bien que dans les éruptions des volcans." This requires to be further supplemented by pressure.

It became necessary, therefore, in the application of the experimental method, to ascertain how far heat, water, and pressure could be made to reproduce the principal phenomena of metamorphism. The means to effect this are shown in a series of illustrations, the general principle being to operate upon a glass tube placed inside one of iron. The tubes were exposed to a temperature of about 400° C. during several weeks. It was found that pure water suitably superheated will transform an anhydrous silicate, such as glass, into a hydrated silicate of zeolitic character. A glass, for instance, containing silica 68·4, lime 12·0, magnesia 0·5, soda 14·7, alumina 4·9, was found to lose silica, alkali, and alumina, whilst the relative amount of lime seems to have increased, and the new silicate had fixed a quantity of water.[1]

The results varied according to the different nature of the glass, and of the substance added to the water. Crystals of quartz were frequently formed. A figure is given at page 168 of a slice subjected to polarized light, showing a number of colourless microliths, and a few greenish crystals of pyroxene. The weight of the water which effected all these alterations was only one-third of that of the glass transformed. Obsidians and perlites were also tried with partial success: some crystals of felspar and pyroxene associated with these underwent no alteration, but were "sugared" over with little crystals of quartz. M. Daubrée enlarges on the wonderful results which have thus been obtained in the wet way, even to the production of an anhydrous silicate, such as pyroxene, at temperatures far below the fusing-point of the mineral. The application of these results to the phenomena of metamorphism is obvious, and explains, amongst other things, by the ready liberation of silica from compound silicates, the formation of quartz on a large scale.

The Roman masonry at Plombières and elsewhere, so long in contact with warm mineral springs, affords an admirable instance of "contemporaneous metamorphism." The reaction of the alkaline waters upon the mortar and bricks has resulted in the deposit of chalcedony and of many zeolitic minerals. Microscopic sections of bricks with geodes lined with chabasite, etc., afford very effective pictures, and many interesting chemical details are added. The curious white concretionary substance called *Plombièrite*—gelatinous when moist, and transported and deposited by the water like silica itself—appears, according to Fouqué's analysis, to be a compound or mixture of carbonate and silicate of lime with water. All these results have been effected at moderate temperatures and without pressure. A valuable digest of these facts appeared in the Quart. Journ. Geol. Soc. for 1878 (vol. xxxiv.), where M. Daubrée observes that zeolitic minerals may be considered as a kind of "extract" of the rocks that have been subjected to a continued lixiviation.

Water, he therefore insists, has played an important part in the crystallization both of eruptive and of metamorphic rocks, especially as it permits the crystallization of silicates at temperatures far below their fusing-points; we must thus look to the hydrothermal rather than to the dry way for the explanation of the origin of silicates in a large part of the rocks.

Under these circumstances, and adopting the very comprehensive

[1] Some of the figures in the tables at page 161 appear to have got transposed, as the calculations hardly agree.

word 'metamorphism' in the sense used by M. Daubrée, it will become more difficult than ever to distinguish between altered and erupted masses when viewed merely under their petrological aspects.

Not the least interesting of M. Daubrée's experiments was made with a view to determine how far the capillary infiltration of water could supply the immense quantities used in volcanic eruptions. A suitable apparatus, figured p. 238, enabled the author to demonstrate that liquid water will force its way through a slab of close sandstone against a very considerable pressure of steam. He therefore infers, that in spite of the powerful upward pressure of aqueous vapour, the cooler waters of the Earth's surface do find their way through the rocks themselves, and that what is known as quarry water is nothing but this feeder surprised at the commencement of its downward journey.

The second section of the work, being devoted to mechanical phenomena, is worthy of a separate notice, but there are some subjects discussed which have a chemical bearing. Important experiments were carried on with a view to ascertain how far the decomposition of silicates is effected by mechanical causes. There is probably no question in the whole work which has a more important geological bearing than this, because it enables us to form some idea how the *débris* of crystalline rocks is chemically altered during the process of degradation. Dr. Sterry Hunt has always emphasized this point, and those who question the wholesale introduction of fresh matter into rocks which the ultra-metamorphic school have taught, attach much weight to their chemical composition as controlling the possibilities of alteration.

Orthose in fragments was rotated in a cylinder along with distilled water. When the experiment was performed in an iron cylinder, 3 kilogrammes of felspar, after a journey equal to 460 kilomètres, yielded to 5 litres of water $12\frac{1}{2}$ grammes of potash, with very small quantities of silica and alumina. To effect such a decomposition mechanical division and the solvent action of water must be exercised simultaneously. Curiously enough the presence of chloride of sodium arrests the decomposition. The presence of carbonic acid facilitates the solution, and much silica, as well as potash, is dissolved. Obsidian and leucite are but slightly attacked. In these operations the mud obtained is in such a fine state of division as to render the liquid opaline, and it takes some days to settle: the quantity of potash retained is still very considerable. Such a substance would form the "phyllades" or argillaceous schists which occur in the stratified terranes at different geological stages: these often contain from 6 to 7 per cent. of potash.

Finally, M. Daubrée once more returns to the subject of metamorphism, and having observed that dry clay triturated against itself, had its temperature raised in three-quarters of an hour from 18° C. to 40° C., speculates on the possibility of the transformation of mechanical force into heat in regions such as the Alps, during the period when those forces acted with the greatest intensity. W. H. H.

II.—The Dolomite Reefs of the South Tyrol and Venetia. Contributions to the History of the Formation of the Alps. (Die Dolomit - Riffe von Süd-Tyrol und Venetia. Beiträge zur Bildungsgeschichte der Alpen. Von Edmond Mojsisovics von Mojsvár.) With a Map, in 6 Sheets, of the Tyrolese Venetian Alps, 30 Photographs, and 110 Woodcuts; pp. 552.

THOUGH the title of this work might lead one to suppose that it merely treated of the geological history of the remarkable mountains of dolomite which are so wonderfully displayed in this portion of the Tyrolese Alps, an inspection of the book itself shows that the author by no means confines himself to a single portion of the geology, but traces out with great minuteness of detail the complete history of the different series of rocks, from the Archaic to the Tertiary, as well as the various glacial deposits and the physiography of the district.

As stated in the preface, the portion of the Southern Alps described in this book lies between the Pusterthal on the north, the Etsch on the west, the Piave to the east, and the neighbourhood of Belluno and the Sugana Valley on the south, and contains the well-known Alpine districts of Amperro, Landro, Sexten, Cadore, Zoldo, Agordo, Primiero, Fassa, Gröden, Enneberg, and Brags; the ancient volcanic tracts of Fleims and Fassa, the eastern portion of the great porphyry plateau of Botzen, the granitic island-mountain of the Cima d'Asta, as well as the fruitful valley lands of Sugana and the rich Tertiary basin of Belluno.

The first part of the book consists of a general introduction to the geological history of the Alps, in which are sketched the various formations, the localities in which they occur, their petrological constituents, and their principal fossils. The probable extension of the land and water areas at the different periods, and the relationship of these rocks to those of corresponding age in other parts of Europe, are also given. It is shown that whilst rocks of Archaic, Palæozoic, Mesozoic, and Tertiary age are represented in this region, the principal mountain masses belong to rocks of Permian and Triassic age.

In the second part, which embraces the fifth to the fifteenth chapters, detailed descriptions are given of the sections exposed in the most noted localities of the region, and numerous woodcuts facilitate the explanations of the more complex sections. Dr. Doelter has investigated and described the volcanic districts of Fassa and Fleims, the quartz-porphyry districts and the granites of the Cima d'Asta.

The 16th chapter is devoted to a consideration of the age, structure, and extension of the vast masses of dolomite, of which this Alpine region is largely formed. The author endeavours to prove that these vast ranges of Triassic dolomite were formed as reefs round the crystalline middle-zone of the Alps during a period of depression, and that they may be compared to the great wall-reefs which now border the Australian continent. On the land bordering these reefs volcanos burst out, and to the eruptions from these and submarine volcanos are largely due the beds of tuff and breccia which have been deposited in the areas surrounding the reefs. These dolomitic reefs are mostly poor in fossils, but the author attributes their deficiency in this respect to the same causes which have brought about the obliteration of organic remains in recent coral reefs. The numerous sections figured and described, in which mechanical deposits of tuff and other materials rest on, and occasionally dove-tail into, the steep slope of the reef-like walls of pure dolomite, are strong evidence of what the author puts forward as the main object of this work to prove—the contemporary formation of these deposits of such different characters in the period of the Trias.

The concluding chapter treats of the periods at which the different dynamical forces have operated to produce the present mountain ranges, and the principal direction of the various dykes and faults.

The maps accompanying the book are drawn to the scale of $\frac{1}{75000}$, and no fewer than 47 different geological divisions are indicated on them in different tints. The photographs are produced by the Albertotype process, and give an excellent idea of the physical characters of this Alpine region. This work merits the study not only of those who purpose themselves to visit the region described, but of every student of geology. H.

CORRESPONDENCE.

RECENT PUBLICATIONS OF THE GEOLOGICAL SURVEY OF INDIA.

Manual of the Geology of India, Introduction, chapters xx. and xxi., by W. T. Blanford, Esq., F.R.S., etc.

Palæontologia Indica, Series XIII., Salt Range Fossils, by Dr. W. Waagen.

Sir,—Being the person to whom the geological examination of the Upper Punjab, as well as the Salt Range, has been entrusted, I would point out that in the publications above mentioned many of my statements, as recorded in my Salt Range Memoir (Geol. Surv. Ind. Mem. vol. xiv.) and other papers, have not been accurately reproduced.

In the Manual, although chapters xx. and xxi. are said in a footnote (p. 480) to be "chiefly compiled from data furnished by Mr. Wynne's papers, except where the contrary is stated," there are very numerous instances, unaffected by the last clause of this passage, in which the published statements of my memoir are replaced by others with which I cannot coincide.

So far as mere speculations are concerned, opinions may of course differ widely, but as to statements of fact I adhere to the views presented in my various papers regarding the geology of the Upper Punjab, including the structure of the Salt Range; with which no other officer of the Survey is more fully acquainted than I am myself, while the writer in the Manual has not even seen the ground.

Throughout the introduction to the lately issued part of the Palæontologia Indica, Dr. Waagen repeatedly attacks my classification of the Salt Range Series, giving an even less definite one of his own, and while condemning that which I adopted, never makes the least allusion to the facts; that mine was based upon the general determinations of our Survey palæontologists (and others), of whom he was then one; also that this classification was made in his own presence, in consultation with himself, without his offering a single objection to it at the time, when specially deputed to assist in the interpretation of the ground. He implies that I treat these local divisions as "real formations equal in importance to 'Silurian, Devonian,' etc. (p. 2)," and says (p. 6) that I appear to have considered the older division of the series "as equivalent to the whole Palæozoic series as it has been defined in Europe and elsewhere."

So far from these statements being correct, I referred the recognizable divisions of the series, on the best palæontological evidence available, to their general ages as "rock groups"[1] merely—and not as "formations" with the definite sense Dr. Waagen would attribute to my words,—leaving the ages of the unfossiliferous zones uncertain, distinctly stating, at p. 281, there was no reason to assert the presence of a Devonian group, and pointing out at p. 118 that considerable intervals were left unrepresented.

Dr. Waagen *now* classes the *Obolus* beds, or Silurian zone of my series, with the *Productus* limestone of his list in one division; entirely omitting to mention that this Silurian zone was originally founded upon Stoliczka's determination of the fossils I obtained from it, confirmed by himself.

His statement (foot-note to p. 3) that Dr. Fleming and I considered *Terebratula* (*Waldheimia*) *Flemingi* (belonging to the upper part of the series) to be Carboniferous, is simply without foundation, so far as I am concerned (see my Memoir, p. 104, where it is mentioned as coming from a higher stage; and section, p. 190, No. 11, where a *Terebratula* supposed to be the same is noticed on the evidence of Dr. Waagen's own notes). I was quite aware of Mr. Davidson's remarks regarding this fossil, but left the settlement of such a point as a matter of course to the Survey palæontologists.

Dr. Waagen further accuses me of wrongly grouping his sections, which in all cases I copied from his own dictation in English; but in one to which he refers at p. 30, owing to his own omission of the groups, I had to supply these from comparison with others. If there are errors in these sections, the fault is his own, and the grouping into which they were thrown at the time is proof of Dr. Waagen's assent to the classification then adopted without reservation or condition on his part.[2]

With regard to this classification generally, now altered by Dr. Waagen, it will be observed he gives no reason at present for questioning the accuracy of Stoliczka's (and his own) determination of the *Obolus* or *Siphonotreta*, on which the Silurian age of one division was based, preferring to attribute error to myself alone.

And further, in referring to the peculiar fish teeth from Chel Hill

[1] See chap. iii. of my Memoir referred to.

[2] See his subsequently written paper, Mem. Geol. Surv. Ind. vol. ix. p. 351, where, notwithstanding some uncertainty stated in the text, he uses the words "*Carboniferous deposits of the Salt Range*" in the title, and indicates elsewhere the Carboniferous affinities of certain fossils of the Range. This shows that the Lower Salt Range limestone was then referred to the Carboniferous period by others on the Indian Survey, as well as by myself.

(of which I certainly forwarded several specimens), my full account of their discovery (Memoir, p. 145) and locality has not been given, and my suggestion that they came from the horizon of this same *Obolus* zone, rather than that of the Magnesian sandstone, has been omitted.

My statement as to the absence of unconformity in the Salt Range is indorsed at p. 2 (wherein he differs from the views presented in the Manual), but he seeks to establish breaks in the perfectly consecutive and stratigraphically united series, both on palæontological and other grounds; overlooking the point that the perfectly united fossil-bearing groups distinguished as Carboniferous and Triassic, Jurassic and Cretaceous, in my list (Memoir, pp. 66, 96, and 277)—from one to another of which some genera at least pass upwards—must be considered more definitely related to one another than any of them are to the equally physically united but unfossiliferous groups beneath.

One of these unfossiliferous groups at a higher stage in my list, No. 8, the red Trias (?), is entirely omitted from Dr. Waagen's transcript of my classification at p. 3 of his paper. Though dealing with other Azoic groups, he seems to have been unable to find a place for this one, leaving it suspended in the anomalous position of Mahomet's coffin.

As a matter of fact, there is little choice as to which of the Salt Range groups are most closely associated or most distinctly divided by stratigraphic features; difference of colour and texture, more or less sudden change, or apparent local transition, being characters observable with varying intensity along most of the boundaries; still I had little difficulty, except in one or two cases, in identifying each group of the series as on a distinct horizon.

Should Dr. Waagen's palæontological labours improve the classification I adopted after consultation with him (as above stated), it will be a welcome result. I regret, however, that his indiscriminate imputations of error compel me to state the actual share taken by him in what had been done previously.

A. B. Wynne,
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JUKES'S THEORY OF RIVER VALLEYS.

Sir,—Mr. Kinahan's reply to my letter on this subject is so extraordinary that I must crave space for a few further remarks.

In his book on Valleys, Fissures, etc., he devotes several pages to the discussion of Jukes's explanation of the river valleys in South Ireland, and from one of these pages I quoted a statement referring to the limestone of that district; yet he now "explains" that the extract "refers to the formation of valleys in any country and in any kind of rocks."

I maintain that the passage cited has no sense unless it refers to the South of Ireland and to Jukes's theory.

Admitting that Professor Jukes in 1862 did believe that the Carboniferous Limestone was *originally deposited* over the whole of S.W. Ireland, yet the theory then enunciated by him in no way depends upon the truth of this supposition. Jukes never supposed the limestone to have had this extension *at the period when the erosion of the valleys was commenced;* on the contrary, his theory is expressly based on the supposition that the surface over which the rivers originally ran was a plain of marine denudation, cutting across the folds and contortions of the rocks.

Mr. Kinahan now affirms that the Carboniferous Limestone thins out southward, and that its original thickness in the valleys of the Lee, Bride and Blackwater was not so great as Jukes had supposed; but, assuming this to be true, the argument which Mr. Kinahan founds upon this premiss is equally defective in logic and in grammar;—he thinks that "as the theory was founded in a county and on suppositions which were afterwards found to be erroneous," he is justified in saying that it falls to the ground. I can only express my astonishment that Mr. Kinahan should consider any part of his own country to be erroneous,—the imputation is so utterly inconsistent with his patriotism that in a Dogberry sense it seems to be "flat burglary." As regards the erroneous supposition (for there is only one), my answer is simply that Jukes's theory was not founded upon it; Mr. Kinahan himself admits this in the passage I quoted from his earlier work, distinctly saying that it did not much affect the subject, "as some of *the* other rocks are nearly as easily denuded as limestone."

It will be obvious to others, however, that, if the thickness of the limestone was never sufficient to fill up the troughs to the level of the original plain, their centre would be occupied by a strip of Coal-measures; and that Jukes's reasoning would still remain the same, for his theory does not depend on the universal presence of limestone, but on the fact of the rocks in the synclinals being more easily denuded than those of the anticlinals.

Having entered the lists in defence of my late uncle's views on this subject, I am glad of the opportunity of noticing a difficulty raised by Prof. Hull in his "Physical Geology of Ireland." Prof. Hull accepts the theory in general, but dissents from its application to the Blackwater, because the point where the present river is deflected southward does not coincide with the influx of any stream from the north. But Jukes's main object was to explain the formation of the transverse ravines, and he looked back to a time when the longitudinal part of the Blackwater Valley did not exist, and when the two brooks from the north "may have united their waters somewhere about the northern end of the Dromana Ravine." I am quoting Jukes's own words, and feel sure that were he now alive he would make a similar answer, and would add that the present actual point of deflection has been fixed by the subsequent changes in the river-course since the establishment of the Dromana Ravine. I trust that Prof. Hull will reconsider this point before bringing out a second edition of his work, and may see his way to accept the theory without excepting the Valley of the Blackwater.

GEOL. SURV. OF ENGLAND, A. J. JUKES BROWNE.
ALFORD, *Aug.* 8, 1879.

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ORIGINAL ARTICLES.

I.—On the Classification of the British Pre-Cambrian Rocks.[1]

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

THE results obtained of late years, through the numerous investigations which have been carried on amongst the Pre-Cambrian rocks in Great Britain, combined with the important discoveries of many additional areas to those previously known, seem to require that some general attempt should now be made to correlate the principal groups where they have been observed; and to classify them according to the prevailing types of rocks recognized therein, and peculiarities observable.

It will be seen that the ordinary methods of investigation, used in determining the order of succession in more recent strata, are equally applicable to these; provided, we grant, that they were deposited more or less in a similar manner, and that the crystalline or semi-crystalline state in which they are now found has been subsequently induced.

This being allowed, we arrive at the probable conclusion that the sediments which hold the lowest, and hence the earliest position, are those which have undergone most change; and that this will be less marked as we ascend in the succession.

I believe that the facts obtained go to prove almost conclusively that this is the case: and, moreover, that the majority of the rocks now recognized as Pre-Cambrian were originally sedimentary strata, which have undergone, during subsequent changes, a certain amount of alteration, or metamorphism, but which still retain sufficient evidence of their origin to warrant their being classified by the same methods as those applicable to more recent deposits. That they can in fact be distinguished by special characters due to the prevalence of certain physical conditions at the time of deposition, by a well-defined order in succession, and usually by a discordance in the strike of the larger groups.

In the physical history of our globe, nothing, perhaps, becomes more evident than the well-recognized fact that its crust has been

[1] Read at the Meeting of the British Association at Sheffield, 1879.

undergoing periodical contractions along certain defined lines. That these lines have also periodically varied in their direction is well known. If we require therefore to trace out the history of these movements, we must seek for it in those strata which we know must have been elevated at the time; and whose beds must have generally assumed a strike parallel with the upward movements. Sir R. Murchison years ago pointed out the fact that the majority of the crystalline rocks in the Hebrides and North-western Highlands of Scotland had a strike from N.W. to S.E.; and hence in a direction not usual in the Cambrian and Silurian rocks.

This fact has been more or less qualified by all subsequent observations, and it is one which cannot be lost sight of in any inquiry made as to the early physical history of our islands. My own observations tend to show that the oldest known upward movements were in a direction almost due *east* and *west*, that is, that the contractions took place from north to south; subsequent elevations and depressions in a direction from N.W. to S.E.; more recent ones from N. to S., and those which immediately preceded the Cambrian period from N.E. to S.W. Each of these produced new physical conditions, with breaks in the succession along well-defined, and usually extensive, lines. Another important fact made out in these inquiries is that it may be possible sometimes to determine the age of the faults by the direction which they have taken, especially if of great extent. For example, a tolerably rigid crust under the influence of a lateral thrust acting from E. to W. would most probably fracture in a direction from N. to S. Now if we take for granted that the last sediments deposited previous to this lateral pressure being exerted were in a condition to yield readily to the contractions, as they probably would be; but that the underlying rocks would be in a hardened or metamorphosed state; it is clear that these last only would be fractured. If these movements also did take place in the direction of those which had previously acted upon these rocks, then generally the fractures would be across the beds, and in the direction of the curvatures of the overlying sediments. That is to say, the faults affecting A would be in the direction of the strike in B.

At present it is difficult to separate always those which may be called the primary faults from those produced subsequently during fresh contractions; still they may be recognized frequently, and when they are they aid greatly any attempt made to unravel the early physical changes. The oldest faults which can be traced with certainty are in a direction from N. to S. and were produced at the close of the Arvonian. They cut across the beds of the Lewisian, and Dimetian, and exposed these rocks as ridges in the Pebidian sea, and Pebidian beds are now seen resting along the sides and unconformably across the edges of these rocks. These faults therefore prove, along with other evidence, that the former rocks were crystalline ere the latter were deposited, and that they yielded by fracturing to the lateral pressure exerted from E. to W. which gave the direction of strike to the Arvonian group.

In former communications I have attempted to classify these rocks as exhibited in special districts, and I have usually found, when examining new areas, that the order which I had previously made out, as far as that evidence went, was almost invariably recognizable there also. It is this fact that has mainly tempted me to bring forward this paper to endeavour to show that a classification generally applicable to the British Islands is even now possible.

Four well-defined groups are made out, and to each of these names have already been given.

They occur in the following ascending order :—1. *Lewisian*; 2. *Dimetian*; 3. *Arvonian*; and 4. *Pebidian.*

1. The *Lewisian*, so named by Sir R. Murchison to indicate the crystalline rocks of the Hebrides and North-western Highlands of Scotland, is here retained for the oldest group at present recognized in Britain, and largely developed in the Hebrides. It is found also in parts of the Malvern chain, and the North-west of Ireland; and possibly also in Anglesey. The prevailing rocks in this group are massive gneisses, in which hornblende and a reddish felspar are the chief ingredients, and quartz, chlorite, and mica, but sparingly present. They are usually of a dusky red, grey, or dark colour. Sometimes almost a pure hornblende rock is found. The strike in these beds is usually E. and W. or some point between that and N.W. and S.E.

2. The *Dimetian.*—This group is largely developed in Wales, as at St. Davids, Carnarvon, Rhos Hirwain and Anglesey. It has been found by Dr. Callaway in Shropshire, and I have recently seen it in the Malvern chain, especially in the Worcester Beacon. I noticed it also last year in large development at Ben Fyn, Loch Maree, and near Gaerloch in Ross-shire, as well as at several other points in the North-western Highlands of Scotland. The prevailing rocks in this group are granitoid and quartzose gneisses, with pinkish, flesh-coloured, or white felspar; and with limestones, micaceous, and occasionally chloritic and hornblendic bands. Brecciated beds also occur in which bits of the older Lewisian gneiss are sometimes found. The strike is generally N.W. and S.E. or from this to N. and S. It evidently overlies the Lewisian unconformably in the areas where both have hitherto been found associated; and its highly quartzose character and lighter colour generally is in marked contrast to most of the members of that group.

3. The *Arvonian.*—At the last meeting of the British Association I mentioned, for the first time, the discovery, or rather the separation of this group. It is largely developed in Pembrokeshire and Carnarvonshire. It occurs also in Anglesey and Shropshire, and I have recently found it at the base of the Harlech Group in the heart of the Harlech Mountains. I have seen masses of it also from the Orkneys, and it probably occurs both in the Western Islands, and in the Grampians of Scotland. It is the great hälleflinta group of the Swedish geologists, and the petrosilex group (Hunt) found so largely developed in North America. It is chiefly made up of

quartzo-felspathic rocks, sometimes porphyritic, frequently brecciated; and of compact quartzose rocks or hälleflintas, which on microscopical examination have the appearance of incipient gneiss. The strike is usually about N. and S.

4. The *Pebidian.*—This being the newest group in the Pre-Cambrian rocks is the least altered in character, and most nearly approaches in strike to the overlying unaltered or Cambrian rocks. It resembles that group in many of its rocks, and on that account was for a time supposed to be identical with it, only that it had undergone local alteration. Now we know that it underlies the latter unconformably, and that the apparent similarity in character is to be attributed to the fact that most of the Cambrian rocks were derived from the denudation of this group. That it was also in a high state of alteration before the Cambrian rocks were deposited upon it is evident from the fact that an abundance of pebbles and masses of it occur in the conglomerates at the base of the Cambrian. It consists for the most part of chloritic, talcose, felspathic, and micaceous schistose rocks; alternating with massive and slaty greenstone bands, dolomitic limestone, serpentine, lava-flows, porcellanites, breccias and conglomerates. It is traversed also frequently by dykes of granite, dolerite, etc. It is a group of enormous thickness, and is largely distributed over Great Britain. It occurs in many parts of Wales, in Shropshire, and in Charnwood Forest. I found it also last year in the North-west of Scotland, and I have seen specimens of it collected by Mr. James Thomson and others from Islay, and other of the Western Islands. Dr. Hunt recognized it also along the Crinan canal, and in the vicinity of Loch Foyle, in Ireland. It is probably represented in America by the Huronian Group. The prevailing strike is N.N.E. to S.S.W., or from this to N.E. and S.W.

The conglomerates at its base are largely made up of masses derived from the Arvonian; and it is undoubtedly, at most of the points examined, unconformable to that group.

These four divisions comprise at present all that we know of the Pre-Cambrian rocks in Great Britain; but it is probable that as fresh discoveries are being made others will still be found. In any case the field is a wide one, and it has at present only been barely touched, though the results have been very considerable. Many, indeed the majority of the rocks found in these four divisions were until recently supposed to be either intrusive masses, or altered sediments belonging to tolerably recent times. The success obtained of late in their separation and recognition has been largely due to microscopical examination, for the first application of which to that purpose we are mainly indebted to Mr. Sorby. In addition to this, it is becoming more and more an acknowledged fact that the metamorphism of great groups of rocks does not take place as readily as was formerly supposed, but that some special conditions, such as do not appear to have prevailed over this area since Pre-Cambrian times, were necessary to produce so great a result.

II.—On some Columnar Sandstone in Saxon Switzerland.

By Walter Keeping, B.A., F.G.S.

(Late Professor of Geology in the University College of Wales.)

ONE of the most beautiful examples of prismatic jointing that we know of in a sedimentary rock has lately come under my notice whilst travelling in N.E. Germany.

In a series of lithological specimens exhibited in the Dresden Museum to illustrate the Cretaceous Period is a tray of small sandstone columns remarkable for their great regularity of size and sharpness of outline. By the favour of Herr Deichmüller (to whom I am indebted for many other acts of courtesy and kindness) I was directed to the exact spot in the Meissener Hochland, or 'Saxon Switzerland' as it is more commonly called, where they were found.

On many accounts the Saxon Switzerland is interesting to the student of joint structure. It is a beautiful country, made up for the most part of the well-known Quader Sandstein, of Upper Cretaceous age—well exposed along the steep natural cliffs of the Elbe River and in the numerous quarries along its banks. The rock is a rather thick-bedded pale yellow sandstone, usually with casts of fossils, readily worked with the hammer and chisel. It is well cut up naturally by two sets of joints running at right angles to one another, which are so regular as to divide it conspicuously into large cubical blocks—on this account the name 'Quader' was given to the formation. According to A. von Gutbier[1] the joints are very persistent in direction throughout the whole district of the Quader Sandstone hills, running from N.W. to S.E., and N.E. to S.W. respectively. Further up the Elbthal and in its tributary valleys this cubical jointing is even more striking. Looking, for example, across the Amselgrunde to the opposite cliff, we have presented to us the appearance of a colossal wall of regular, gross masonry about 500 feet high; and, again, all those extraordinary and characteristic features of this remarkable country—the deep narrow chasms and ravines, perpendicular cliffs, sets of pinnacles and outstanding columns—have for their *existenzgrund* this same regular, cubical jointing.

But leaving these more varied and picturesque parts, and turning southwards up the country from Schandau, we come to the hill known as Gorischstein, where occurs that particular prismatic sandstone which it is the purpose of this paper to describe. It is curious how little known this section is. I have only been able to find a single account of it in German or English literature, namely, that by von Gutbier already referred to above.[2]

The quarry is on the east side of the hill called Gorischstein, at a height of 1150 ft. above the level of the sea. It is but a small opening, no longer worked, which may be detected by the basalt

[1] Geognostische Skizzen aus der Sachsische Schweiz und ihrer Umgebung, 1858, pp. 30—31.

[2] I am indebted to Herr Deichmüller for an account of this description by A. von Gutbier.

"metal" on the road of approach. On entering it, evidences of former volcanic activity are seen in some rubbly basalt-ash on one side. A closer search is necessary, in the present condition of the quarry, to find the mass of the basalt in the floor of the quarry. This proves to be a very hard, close-grained olivine basalt, excellent for road metal, and, as recorded by Gutbier, columnar in structure.

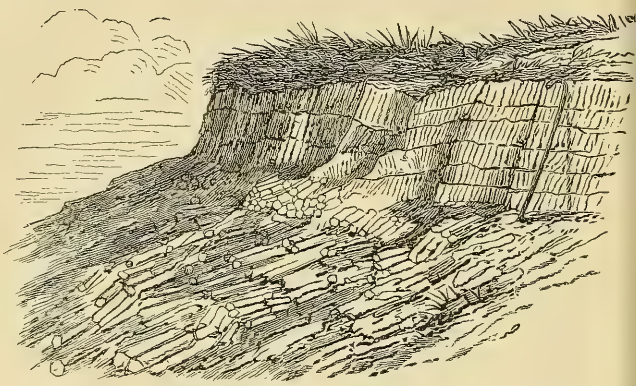


Fig. 1. Columnar Sandstone as seen in a quarry at Gorischstein, West of Schandau, "Saxon Switzerland." (A walking stick is placed against the bank as a scale of height.)

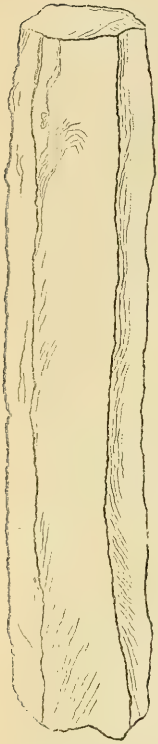


Fig. 2. A Single Column of the Natural Size.

We may pause for a moment to consider what are the petrological aspects of this mass of basalt: whether it was a dyke, sheet, or "neck." There can be little doubt that it was an old neck; for, judging from the contour of the quarry, the horizontal section was circular, and the basalt is a pipe-like mass. At the sides of the quarry ashy materials are still to be seen. A small cinder-cone probably once capped the ground above.

On one side of the pit some loose sandstone prisms, small and regular like those in the Dresden Museum, are scattered over the slope, but these are only part of the *débris* fallen from the pit sides higher up. In the undisturbed quarry-face above they are seen in astonishing perfection, as indicated in the annexed woodcut (Fig. 1), which represents a drawing of part of this exposure. Here, facing the spectator, is a series of tiers of colonnades made up of regular prisms. Those nearest the front lie nearly horizontal, whilst as we recede into the sandstone they approach more and more towards the vertical, till, at last, about two or three feet from the outer series, the columns stand perpendicular; so forming altogether the regular curve seen in the woodcut. Now this curving is not produced to any important degree, by a binding of the prisms themselves, but is due to the gradual and regular variations in the directions of the columns in the several tiers of prisms. The wondrous regularity of the columns and their small size are particularly striking in this exposure, viz. they are nearly all from three inches to five inches long, and little more than half an inch thick (see Fig. 2, natural size). They are by no means constantly hexagonal, but vary from three- to seven-sided. In all, however, the faces are clean and well defined, and the angles sharp. The rock material of which they are composed is a brittle sandstone, so hard that the columns clink when struck against one another, but loose and porous in appearance when examined on a broken surface. On such fractures it is seen to be made up of small irregular quartzose grains, which look as though fused together at their edges, but with vacant spaces as great as themselves left abundantly amongst them. Towards their exterior the columns are more compact, and upon the joint surfaces themselves the quartz grains are more or less fused together; indeed, we may often see here a continuous layer of vitreous quartz over a small area, where the outlines of the component grains are only indicated, if at all, by such a granular appearance as is seen in a compact quartzite. It is as though each prism had been half fused in a hot mould, so that the clean surfaces and sharp angles were most altered by the heat, and the interior was less so.

There is no such special structure on the joint surfaces of the ordinary Quader Sandstein. Comparing the fractured surface of one of these columns with rock specimens from the ordinary Quader Sandstein, I cannot detect any very striking differences between them. The columnar rock is even of looser build, internally, than usual; but the whole column is harder and less easily crumbled than the unaltered rock, this being especially the case with the surface layer.

A microscopic examination and comparison of prepared thin sections of the two kinds of rock, the altered prismatic and the ordinary sandstone, does not yield us any special characteristics of distinction. Professor Bonney, who has kindly examined the slides, writes concerning the columns, that they "consist of angular to rather rounded quartz grains, with one or two which may be decomposed felspar, cemented by a rather abundant dark substance (quære if this be not in part discolouration from powder used in preparing the slide, as the texture is rather open). In the quartz many minute inclosures, almost always less than ·001″, appearing when highly magnified of a pale purplish colour, and in form rather like irregular tubes. In one or two there was an appearance which might indicate a very minute bubble, but in most cases there was no sign of this. Very little difference between the two slides, except that the cementing substance in that from the column is paler, and the quartz grains look a little cracked."

We may next notice the well-marked layers in which the prisms are arranged. This is in no way connected with stratification lines of deposition, but is a superinduced joint-structure such as occurs not unfrequently in prismatic basalt masses, *e.g.* in the great basalt quarry above Forst, near Durkheim.[1] It is the "Tabular" structure of Professor Bonney. In these altered prismatic Saxon sandstones this structure is unusually regular, dividing the rock into zones about 4 inches in thickness.

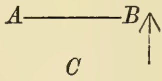
According to A. von Gutbier, an irregular line of clay ironstone 4 to 5 inches thick, and next a zone of "reddish green steinmark," intervened between the sandstone columns and the basalt.

Next, to inquire into the mode of origin of these prisms and their associated structures. The production of columnar structure by contraction during cooling or drying is now very well understood; being well illustrated by the structure of dry starch on the one hand, and in the artificial formation of columns in the sandstones of furnaces on the other. The evidence of the former presence of heat in close proximity with the Gorischstein prisms is obvious enough, for the outermost sandstone columns were almost in contact with the liquid lava mass. But whether the heat was also the immediate cause of the prism of the quartz grains, as above described, on the surfaces of the columns, is not quite so clear; though the fact of its special association with the prismatic structure must not be overlooked. There is no evident reason why the deposition of silica in the wet way should go on over the prismatic joints differently from that over the ordinary rock joints, except during that special period of cooling when the columnar joints were in course of formation. I am therefore disposed to refer this alteration of the superficial layer of the prisms to the later stages of the volcanic period, when such joints would have served for the passage of heated water or of steam to the surface.

Note by the Rev. Professor Bonney on the origin of the curved arrangement of the prisms.

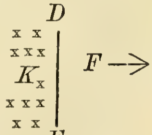
The rock in order to break requires (1) that its temperature should be considerably elevated; (2) that this should be again gradually lowered.

A surface of uniform temperature is a surface of uniform tension.



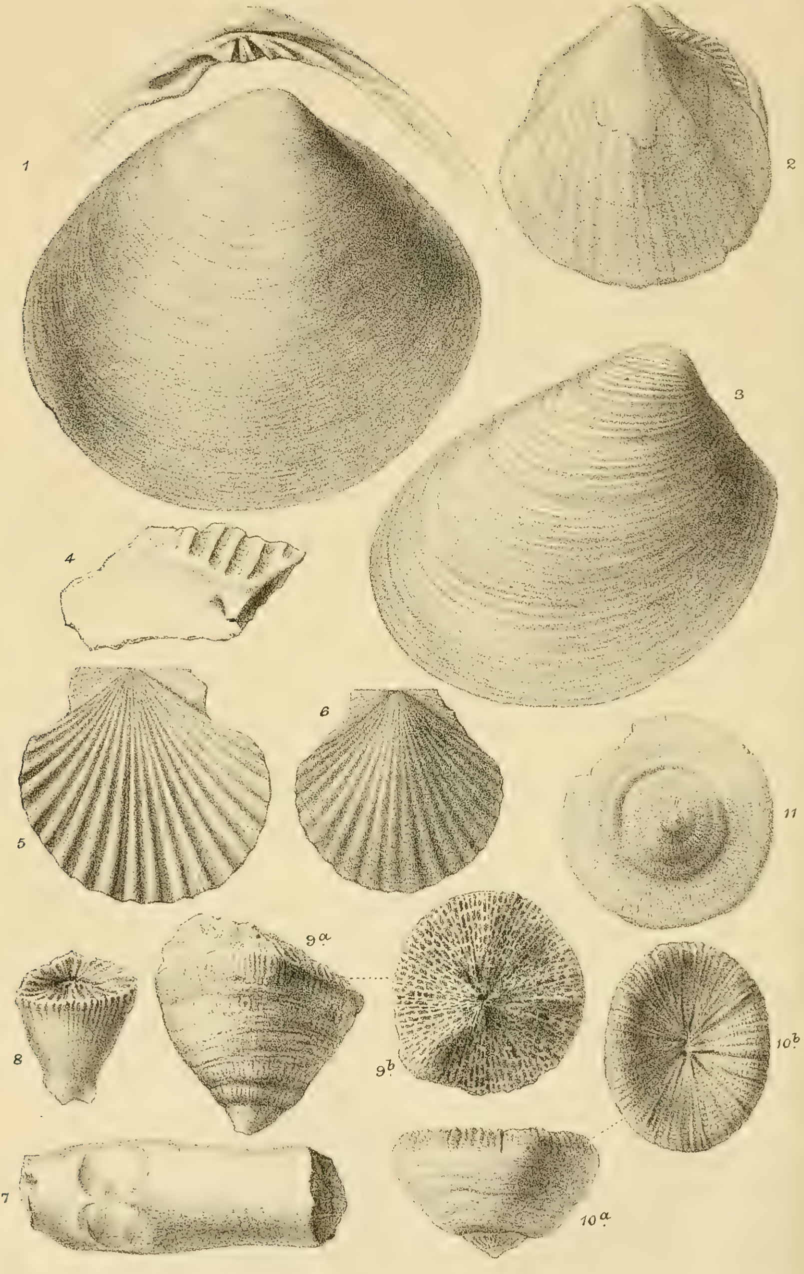
Now if *A B C* be a heated mass, losing heat principally from *A B*, a rock at surface, the surface of uniform tension lies parallel to *A B*.

Again, if *D E F* be a mass in contact with an igneous rock *K* at some depth, the main loss of heat will be laterally, and so the surface of uniform tenison be vertical and the columns horizontal.



At the top, then, the loss of heat will be mainly from the top; deep down mainly laterally. Thus the surfaces of equal tension will descend in the mass radially, the lateral loss producing no effect at first and *vice versa*. So that I take it just at first the columns should lie pretty nearly parallel with the basalt,

[1] Quite a distinct thing from the bedding of successive lava flows. See Prof. T. G. Bonney, Quart. Journ. Geol. Soc. vol. xxxii. p. 145.



C. L. Griesbach del. et lith. West, Newman & Co. imp.

Sumatran Tertiary Shells & Corals.

and at last become perpendicular; of course the top layers will be formed long before the bottom.—T.G.B.

In a paper on "Columnar, Fissile, and Spheroidal Structure," read before the Geological Society (Q. J. G. S. vol. xxxii. p. 141), the Rev. Prof. Bonney has given a list of examples of columnar structure in non-igneous rocks. Amongst these the altered clay bed in Tideswell Dale[1] most nearly resembles our Gorischstein prismatic sandstones. But the Yorkshire clay prisms are from 1 to 6 inches thick and 8 to 9 feet long (Mello), and the columns themselves are curved, as is common in basalts, etc.

In addition to the examples mentioned in the paper above referred to, Prof. Bonney now tells me of a columnar sandstone underlying basalt from Johnsdorf, near Zittau, Saxony; ironstone, columnar from burning, exhibiting bent, wavy and radiating columns, about $\frac{1}{12}''$ diameter, from South Wales; and columnar sandstone from furnaces in Wales, Staffordshire, and Russia—all of which may be seen in the Museum of University College, London.

Another good example of this structure was observed by my friend Mr. A. F. Griffith, of Christ's College, last year, near Clermont, Auvergne. It occurs in a pale marl under the old lava flow of Graveneine near its extremity, about three-quarters of a mile from Clermont on the Issoire road. Here a quarry has been opened so as to expose some 12 feet of the lava; beneath this is a zone of porcellanized material, irregularly jointed, and about two inches thick; and next below comes a layer of diminutive hardened columns 5 or 6 inches in thickness. The better prisms are about 4 inches long, and $\frac{1}{2}$ inch across; but others are not more than $1\frac{1}{2}$ inches long. Beyond the limits of the lava, the prismoidal clay is seen to pass into a pale freshwater marl. Mr. Scrope[2] has described a similar case near St. Saturnin beneath the lava current of the Puy de la Vache.

III.—Further Notes on a Collection of Fossil Shells, etc., from Sumatra (obtained by M. Verbeek, Director of the Geological Survey of the West Coast, Sumatra). Part II.[3]

By Henry Woodward, LL.D., F.R.S., etc.;
of the British Museum.

(PLATE XI.)

AMONG the Conchifera transmitted by M. Verbeek, is a specimen of *Cyrena*. The shell is certainly from a very modern formation, as it retains its translucency and traces of a pale buff colour externally.

19. *Cyrena sinuosa*, Deshayes. Pl. XI. Fig. 1.

Mr. Edgar Smith, after comparing this specimen with recent *Cyrenæ* in the collection, observes, "The outline of this valve is

[1] Described by the Rev. J. M. Mello, Quart. Journ. Geol. Soc. vol. xxvi. p. 701, and Geol. Mag. Vol. VII. p. 520.

[2] Volcanos of Central France, p. 92.

[3] Continued from the September Number, p. 393.

precisely like that of *Cyrena sinuosa*, and the faint shallow groove down the posterior side is likewise traceable. The hinge-teeth both in form and number also agree."

The following is Deshayes' description of this species from the Proc. Zool. Soc. 1854, p. 18 :—

"Shell ovato-rotundate, tumid, cordiform, solid, very inequilateral; epidermis dark russet-colour, covered by slender transverse ridges; anterior end short, rounded, subtruncated posteriorly; deeply grooved on the upper posterior side, grooves sinuous, decurrent; umbones tumid and short, generally eroded; ligament narrow, partially concealed; valves white within, hinge thick; tridentate on either side; teeth oblique, median and posterior tooth in right valve bifid; lateral teeth short; anterior tooth thick, conical; apex acute."

The recent specimens in the British Museum were obtained from the river Paningbang, Java, and are much thicker than the fossil valve from Sumatra, and have their umbones more eroded.

The thick rough dark olive-brown epidermis and prominent ligament, seen in the recent examples, are of course wanting in the fossil specimen.

Measurement of right valve of fossil, 60 millimètres broad, height 55 mm.

Locality :—Sumatra. (Subfossil ?).

20. *Pectunculus*, sp. (cast of). Pl. XI. Fig. 2.

The casts of this species of *Pectunculus* exhibit a portion only of the interior shelly layer, and indicate a somewhat compressed and internally-ribbed shell, showing also the characteristic dentition of this genus.

Dimensions :—Breadth 35 mm., height 37 mm.

Formation :—Tertiary Clay-marls.

Locality :—Island of Nias, Government of the West Coast of Sumatra.

21. *Venus ? non-scripta*, Sowerby. Pl. XI. Fig. 3.

Trans. Geol. Soc., 1840, 2nd ser. vol. v. pl. xxv. fig. 8.

D'Archiac and Haime, Descrip. Anim. Foss. du Groupe Num. de l'Inde, 1854, p. 246, pl. xvii. fig. 7, 7*a*.

The specimens of this shell obtained by M. Verbeek appear to be identical with the above species described by Jas. de Carle Sowerby from Soomrow, Kutch, India, and also noticed by D'Archiac and Haime as being very common in the yellow sandy limestone of the Hala range in Scinde.

The following is the description of this species, as given by Mr. Sowerby :—

"Transversely oval, convex, smooth, concentrically undulated, lunette elongated, pointed, concave, breaks nearer the anterior extremity, [and strongly recurved]. A smooth and thin shell, with little of the aspect of a *Venus*."

We agree with Mr. Sowerby in assigning this specimen to *Venus with considerable doubt.*

Measurements :—Length 53 mm., depth 50 mm.

Formation and Locality :—The same as the preceding.

22. *Perna*, sp. Pl. XI. Fig. 4.

Two fragments showing the characteristic hinge-line and nacreous interior.

Formation and Locality:—The same as the preceding.

23. *Pecten asper*, Sowerby (*non* Lamarck). Pl. XI. Figs. 5 and 6. 1847, Thesaurus Conch., vol. i. p. 50.

Shell inequivalve, equilateral, ears equal, minutely serrately striated; left valve flat, a little raised towards the umbones, rayed with eighteen rather flatly two-angled ribs; ribs and interstices concentrically striated, dotted everywhere with pale red; right valve convex, rayed with nineteen rather smooth ribs; ribs white, sparingly lineated with red; interstices red towards the margin.

Dimensions of flat valve:—Breadth 33 mm., height 32 mm.

Locality and formation:—The same as the foregoing species.

24. Aspergillum sp., Lamarck. Pl. XI. Fig. 7.

Shell with two equal minute ovate valves, mostly angled posteriorly, soldered into the lower wall of a long sheath; sheath at the upper part open, sometimes attenuated, with the edge simple, sometimes nearly straight, with the edge rather largely two to eight times furbelowed, at the lower part club-shaped, closed by a perforated, generally tubularly, fringed disc.

This shell is probably referable to the recent *A. Javanum*, sp. Brug., or *A. sparsum*, Sowerby, from Java.

Formation and Locality;—The same as the preceding.

25. Zoantharia.—*Acanthocyathus*, sp. Pl. XI. Fig. 8.

Corallum turbinate, compressed towards the base, and broadly attached; calyx elliptical; costæ slightly prominent, extending to the base and minutely granulated; columella elongated and irregular; principal septa 22-24 in number, their surfaces covered by minute styliform processes or synapticulæ.

This coral agrees closely with the specimens of the living *Acanthocyathus Grayi*, in the British Museum, from the seas of Australia and Japan, but the fossil examples have not the prominent lateral shoots seen in that species.

Formation:—From grey sandy-clay rich in Gasteropoda, Tertiary.

Locality:—Island of Nias, Government of the West Coast of Sumatra.

26. *Montlivaltia*, sp. Pl. XI. Figs. 9 and 10.

Corallum subturbinate, slightly attached, epitheca moderately thick; calyx subelliptical, fossa moderately deep, with about 50 septa, the majority of which reach the centre; upper surface of septa imbricated.

Fig. 9 *a, b*, appears to be only a more conical variety of the same species and its fractured state exposes the dissepiments connecting the septa (see Fig. 9 *b*).

Formation:—Tertiary Clay-marls.

Locality:—Island of Nias, Government of the West Coast of Sumatra.

27. *Fungia*, sp. Pl. XI. Fig. 11 (under-side).

A nearly flat discoidal form with minute projecting point of attachment, as seen in young examples of the common recent *Fungia*. Costæ minute, numerous, extending from centre to circumference.

Septa excessively numerous, the longer ones alternating with the shorter; septa or pali, furnished with numerous synapticulæ.

Formation and Locality:—The same as the last-named species.

EXPLANATION OF PLATE XI.

Fig. 1. *Cyrena sinuosa*, Deshayes, subfossil, Sumatra.
,, 2. *Pectunculus* (cast of), Tertiary Clay-marl, Island of Nias, W. Coast of Sumatra.
,, 3. *Venus ? non-scripta*, Sby., Island of Nias, W. Coast of Sumatra.
,, 4. *Perna*, sp. (fragment of hinge) ,, ,,
,, 5. *Pecten asper*, Sby. (flat valve) ,, ,,
,, 6. ———, Sby. (convex valve) ,, ,,
,, 7. *Aspergillum* (*Javanum* ?) ,, ,,
,, 8. *Acanthocyathus*, sp., Tertiary, Grey Sandy Clay, Island of Nias, West Coast of Sumatra.
,, 9. *Montlivaltia*, sp., (*a*) side-view; (*b*) view of top.
,, 10. ———, (*a*) side-view; (*b*) view of the interior of the calyx. Tertiary Clay Marl, Island of Nias, West Coast of Sumatra.
,, 11. *Fungia*, sp. (view of under-side), *loc. ibid.*

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

IV.—On the Cudgegong Diamond Field, New South Wales.[1]

By Norman Taylor, Esq., of the late Geological Survey of Victoria.

Communicated by R. Etheridge, jun., F.G.S.; of the British Museum.

The next appearance of the *older* lead is at the "Rocky-ridge," where the river, after running northerly for three-quarters of a mile, along the strike of the metamorphic beds, turns abruptly to the west. This ridge is a basalt-capped hill on the north side of the river, running in a north-west direction; it is about a mile long, with a bold rocky escarpment on its west side, facing the Sandy or Cudgebeyong Creek. Some tunnels have been driven in, and shafts sunk on this hill, and tolerably rich deposits of gold were found, but never followed out. Only in the southern half of the hill have diamonds been found (all more or less spotted). The drift is remarkable for the number and size of the agates it contains. The northern half of "the ridge" is underlaid by another outlier of the before-mentioned doubtful purple conglomerate, into which some tunnels have been driven in the western escarpment. The basalt is merely a fringe here, resting against the flank of the conglomerate hill to the east. A few inches of drift rest upon this conglomerate, in which a small quantity of nuggetty gold was obtained; and from one to two inches thickness of lignite, or carbonaceous clay, is seen between it and the bottom of the basalt. The basalt is intersected by numerous veins of a mineral allied to kaolin. The purple conglomerate is similar in character to that near "the flat," and contains, on some of the joint faces, small spherical crystalline aggregations of chalybite (carbonate of iron). At the extreme north end of "the ridge" are great quantities of ironstone and conglomerate, but, from their mode of occurrence, I should imagine them to be part of the Carboniferous series, which is largely developed further north. The first diamonds which found their way to Melbourne were obtained

[1] Concluded from page 412.

from "the Rocky," at Hill's, or the diamond Claim, in the bend to the south-west in the centre of the hill. A short distance to the east of this claim is Ryan's, from which as much as two ounces of gold to the load were obtained, as well as a few diamonds. Crossing the Cudgebeyong Creek, in the bed of which is a horizontally bedded mass of conglomerate (some part of the Carboniferous series, or possibly Mesozoic), we arrive at another basalt outlier. The hill itself is composed of slates, capped with purple conglomerate. A ring-like fringe of basalt surrounds it, leaving the top uncovered; while between it and the basalt, Tertiary ferruginous cement and drift crop out on the flanks of the hill. The decomposed basalt, from shafts on the north side of the hill, is very full of kaolin. The metamorphic beds crop out again a short distance to the west of this hill. It is difficult to imagine the course taken by the old river from this point; it could not have gone westerly, as the country consists of high schist ranges, intersected by numerous greenstone dykes, running as usual in the strike of the slate rocks. On the south-west flanks of the "Rocky-ridge" the surface is covered with a wash of drift, which is continuous across the river (here running westward) to the "Horseshoe bend." The late Professor Thomson suggested that the basalt, on arriving at the Cudgebeyong Creek, may have flowed or been backed up by this tributary for some distance. The old junction of this creek with the river was probably near the centre of the "Rocky-ridge."

The "Horseshoe bend," on the south side of the river, is a semi-circular basalt-capped hill, having its concave side facing the river, and its convex one resting against the side of the purple conglomerate hill, first mentioned as occurring to the north-west of the "Two-mile-flat." The basalt of this hill, like the others, is underlaid on its north or river side by older drift; the lead dips into the hill on its western side, but it was not rich either in gold or diamonds. A few diamonds were obtained in the shallow ground of the northern concavity, and the associated gems were larger there than anywhere on the whole course of the lead. A fine example of columnar basalt occurs in a shaft at the south-west horn of the hill. Between this hill and Hassall's fence, on the river, the greenstone dyke, west of the "Two-mile-flat," which disappeared under the purple conglomerate-capped schist hill, again crops out, and crosses the river. Its course is now somewhat altered, both it, and the accompanying band of metamorphic rocks, being thrown a few chains to the west, probably by a fault. From the "Horseshoe bend," in about half a mile south-westerly, we reach Hassall's Hill, adjoining Mr. Hassall's property. These hills are separated by a low schist range.

"Hassall's Hill," like the "Horseshoe bend," is nearly semi-circular, with the horns flattened inwards so as to form two parallel shoulders, and with its convexity towards the river,—it consists of basalt overlying older drift. The south-west portion of this hill is lower than the north-eastern, the denudation having only left a thickness of about thirty feet of basalt, whilst at the highest part of the hill there is from 80 to 90 feet. The drift underlies it in two distinct leads, from north to south, in the centre and west of the hill, but not on the east. The leads form a sort of elongated ellipse. The concavity of the hill faces south-west and the horns are nearly connected by the lower or more denuded portion of the flow. In the innermost portion of the concavity, which rises gradually to the table-topped main mass, a shallow hole exhibits a fine friable thin-bedded greyish white sandstone, inclosing perfect, but minute, double hexagonal pyramids of quartz. This is evidently the top of a hill or island, round which the old river, and subsequent lava-streams, have flowed. The denudation not having been so extensive here as on the upper portions of the lead, a greater width of basalt and increased thickness of the underlying drift is the result. In the easterly lead, where it curves round to the south horn, as much as one ounce of gold to the load was obtained; but, from the length of time occupied in sinking the shafts (over five months), it was unprofitable. Some very long drives were put in, and a few diamonds were obtained, but the area was never specially worked for diamonds. The rock on the top of the hill consists of from thirty to forty feet of loose concretionary basalt, getting denser below, and resting on vertical columnar basalt. The whole of the upper stratum has been denuded away from the lower ground. On the south face of the central sandstone hill is a small shallow lead, which must be the edge of the older drift, resting against the sandstone island, and now exposed by denudation. A similar instance occurs again near the apex of the southern horn; where the basalt of the northern horn nearly joins that of the southern one, the ground is quite shallow (about 12 feet deep), but deepens westerly to 30 feet, and contains very large semi-angular blocks of quartz, and much "cement." The south side of the southern horn was worked, and yielded a few diamonds, but not much gold. The drift is full of large semi-angular blocks of quartz, and is a side wash, as the ground dips to the north. The quartz, from its character, is, in a great measure, derived from veins in, or in the neighbourhood of, greenstone. In the deepest parts of the leads the quartz boulders are all perfectly rounded. The richest diamond claim discovered was situated at about the centre of an imaginary line joining the two horns; it was owned by a working party of miners—Messrs. Cooney, Hennessy, Ward, and others. Their shaft, sunk to the depth of 51 feet, shows 27 feet of basalt, resting on brownish-yellow sand, and that again on alternating sandy, gravelly, and pebbly beds, mostly loose and friable, with occasional thin layers of ferruginous "cement." The whole of the drift below the basalt had to be very securely slabbed, as the fine sand runs like water. In their southern drive there are three distinct veins of very loose granitic quartz detritus, separating, and alternating with, the gem-bearing veins. These gradually cut out, going north, and the gem-wash becomes more solid. There is also a bed consisting entirely of loose and open quartz pebbles, superficially covered with a brownish-black greasy-looking coating of oxide of manganese. In one of the drives they cut through what appears to have been a portion of a large tree, lying horizontally in the cement on the "bottom,"—the wood itself had entirely disappeared, and nothing but a hollow casing or shell of oxide of iron remained,—this was internally longitudinally striated, and was composed of several coats. On the inside were some peculiar metallic efflorescences presenting the appearance of small round black velvet buttons, composed of confusedly foliated plates of a substance, which, when rubbed, assumed the metallic appearance of graphite, and soiled the fingers. Fragments of drift wood had been found on the bottom; not silicified like that derived from the Carboniferous rocks. The gem-stones can be traced most thickly in slightly cemented (by silica) flesh-coloured veins. The total thickness of the drift is 24 feet, and the bottom dips westerly. On driving northwards the bottom rose and fell again, and the diamonds became scarce.

Adjoining the above claim was another, belonging to Messrs. Scott and Allen, which was 54 feet deep. The ferruginous "cement" in this claim inclosed abundance of pleonaste, zircon, sapphire, and topaz, with small fragments of brown ferruginous wood, like that occurring in most of the Tertiary cements in Victoria. The "cement" forms but a very small proportion of the drifts, and occurs in irregular thin veins, sometimes fine- and at others coarse-grained. Other shafts were sunk west and east of these rich claims, but unsuccessfully, as they did not appear to possess the few bottom feet which contained the diamonds. To the north of this, and on the river-side of the northern horn, another shaft yielded a very heavy drift, giving an average of one diamond and five pennyweights of gold to the load. The basalt increases in thickness to the west at Hassall's fence, whilst the drift diminishes; a shaft there passing through 32 feet of basalt, and 15 feet of drift. Messrs. Cooney and party had, up to April, 1870, obtained over 1000 diamonds, and Scott's party about 700. The lease of the former party had then been proved for a distance of 300 feet along their main drive (N. 35° W.) with a breadth of over 100 feet. A washing of 33 loads yielded 306 diamonds, weighing $74\frac{1}{2}$ carats (largest $1\frac{3}{8}$ carats). They have washed from 1 to 15 diamonds to the load, but the average was about 5, with 3 dwts. of gold. A washing of from 12 to 15 loads of Scott's gave at the rate of 8 diamonds and 3 dwts. of gold to the load. The small quantity of gold obtained is due to the fact of the diamonds not being on the bottom, while the gold is, and consequently, a thickness of as much as 5 and 6 feet of wash dirt had to be taken out, thus reducing the gold per-centage. The southern face of the northern horn is very shallow ground.

The basalt runs westerly through Mr. Hassall's fence and into his paddock, where it is concealed by alluvial soil, and nowhere crops out again. The diamond ground was supposed to run in that direction, but, being private property, it had not then been prospected.

Between this and the river,—which, after running a mile westerly from the "Rocky-ridge," turns abruptly to the south, and keeps this course for two miles,—we cross another greenstone dyke running in the same direction as those before mentioned, and crossing the river about midway in the bend to the south. There are some extensive alluvial flats between Mr. Hassall's house and the ford, where the Wellington Road crosses, in which some good gold leads may probably exist.

Above this crossing place a rocky bar spans the river, consisting of a dark grey breccia, having a gneissose appearance and associated with flinty beds. About a mile along the road to the north of this, on Mr. Lowe's property, and about 1½ miles due west from Hassall's Hill, is another small basaltic outlier, resting on drift; there are also several drift or "made" hills uncapped by the basalt. These had been formerly worked for gold. Below this there is no trace of basalt for seven or eight miles down the river, till a little below Laby's Farm, at Uumby, where there is a very small outlier on the river bank, but whether the older drift underlies it or not, had not been proved. "Made" hills of drift, apparently the *newer drift*, skirt the river-banks on both sides to its junction with the Macquarie River, but there is no further trace of basalt on the Cudgegong River; although there are outlying remains down the valley of the Macquarie River of a former sheet of basalt, which had perhaps flowed down the valley of that river, and covered up the Tertiary drifts, which have been worked for gold, at a considerable elevation above the present river. The rocks down the river are similar in character to those above, but are less metamorphosed and more shaly, with interbedded brecciated conglomerates. Syenitic granite crops out occasionally, and quartz-reefs are very numerous.

About a mile to the north of the northern end of the "Rocky ridge" there has been a small "rush" (Cunningham's) to a gully and "made" ridge under the schist ranges forming the eastern watershed to the Sandy or Cudgebeyong Creek. A nugget weighing 36 ounces was found there, but no diamonds. The sinking varies from 12 to 20 feet, very little quartz occurs in the wash dirt, and what there is is angular; but magnesite occurs in considerable quantities, both massive in large lumps, and as peculiar curved cylindrical concretions. The ranges at the creek head are everywhere intersected by small quartz veins.

This, then, being the history, at the time of my residence there, of the diamond-bearing localities, I will next enumerate the various drifts and the materials of which they are composed.

There are, on the Cudgegong, at least six drifts of different ages, the oldest of which the late Rev. W. B. Clarke took to be as young as Pleistocene. I differed from his view, and placed them temporarily with Older Pliocene, following my Victorian experiences, and later, in working out the discovery, at the "Welcome rush" near Stawell, Victoria, of a bed of marine littoral fossils overlying a gold drift, I came to the conclusion (see Progress Report of the Geological Survey of Victoria, No. 3, p. 264) that these fossils were probably of Upper Miocene or Lower Pliocene age, and the gold drift under them much older. I am now of opinion, after reading the report of my friend and late colleague, Mr. C. S. Wilkinson (Mines and Mineral Statistics of New South Wales, 1875, p. 77, et seq.), on the Tin-mines of New South Wales, that the older diamond drifts must be of the same age as the older Tin "leads" of Borah Creek, which also contain diamonds.[1]

In ascending order, commencing with the oldest, they would probably occur as follows:—

1. Upper Miocene, or Lower Pliocene. } Older Drift, possibly fluvio-marine, underlying basalt, and containing gold, tin, and gems—no fossils to prove age. This drift may again be sub-divided into two—one containing semi-angular quartz (a reef wash), and the other rounded boulders.[2]

   Lapse of time, during which were formed—
2. Middle Pliocene.—The Gulgong deep leads with plant-remains, the latter described by Baron von Mueller. These leads perhaps drain into an old lake-basin at the head of Reedy Creek.
3. Basaltic overflow, filling lake and flowing down the Cudgegong Valley.
4. Wash of conglomerate pebbles, etc., over the surface of the basalt.
5. Upper Pliocene.—Newer Drift, fluviatile, and derived from all the above during the cutting out of a new river channel. To this or the next division may belong the "leads," higher up the river, containing fossil bones at the Pipeclay Diggings, and cinnabar near the village of Cudgegong.[3]
6. Pleistocene.—The older river channels, now silted up, and below the level of the present river-bed.
7. Recent.—The present river-bed.

With regard to these *older* drifts, it must be borne in mind that they vary much in position; they are below the river-bed at the Reedy Creek, and much above it at the Two-mile-flat, the present river falling at a greater rate than the old river.

The *older* diamond-bearing drift, underlying the basalt, is a coarse and heavy deposit,—some boulders in it weighing several hundred weights,—for the most part loose, but portions of it united into a compact conglomerate. It varies greatly in thickness, from a few inches to 30 feet, according to the irregularities, in some cases, of its own upper surface, which is not uniformly level; and in other cases, due to the old river-bed. Huge blocks of hard slate, sandstone, quartz, greenstone, and felspathic rock, the two latter often decomposed into masses of clay, still retaining the original shape of the boulders, lie at the base of the drift in many parts.

The following are the contents of this drift, which is, however, very variable in different localities: large and small boulders and pebbles of quartz, generally coloured a reddish-yellow or brown externally by oxide of iron; sand of various degrees of fineness; pebbles and sand cemented by oxides of iron and manganese, or by both together, the iron coating the quartz in concentric rings, and

[1] These are considered by Mr. Wilkinson to be of Miocene age.—R. E., jun.

[2] At the time of the formation of the *older drift*, the Carboniferous rocks to the east and south-east may have been above the reach of marine action, and so escaped the denudation; thus accounting for the absence of any traces of them in the drift. The denudation of the Carboniferous rocks may have commenced after the basaltic outbursts, and during the cutting out of the new river valley.

[3] At the Cudgegong cinnabar mine, boulders of coal and sandstone occur in the drifts, with large sapphires and zircons, but no diamonds or topazes, nor did I find ruby, though it is stated to occur there.

Fig. 1. Sketch Section at Reedy Creek.

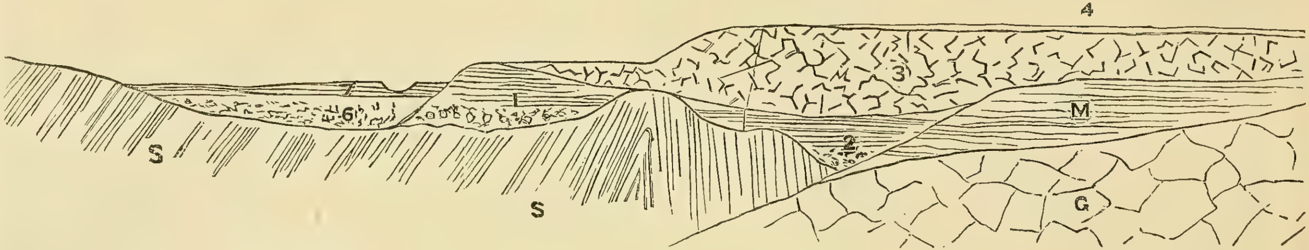
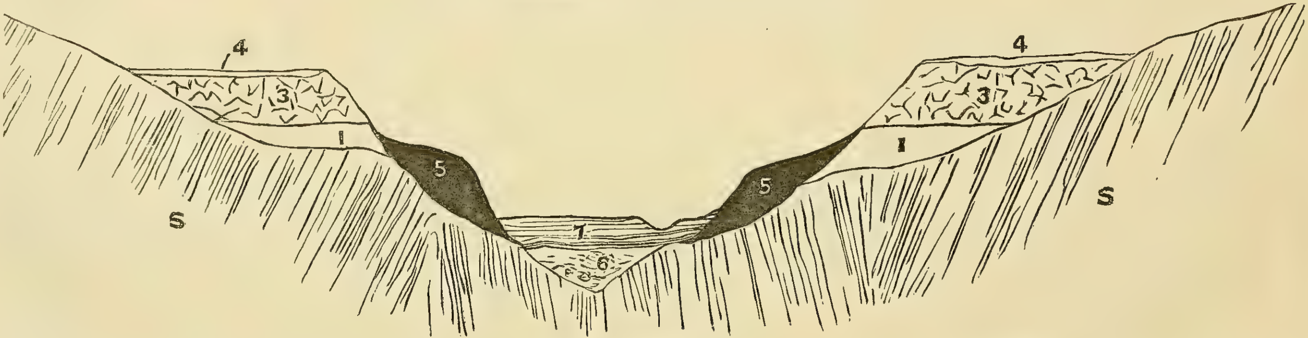


Fig. 2. Sketch Section near Two-mile-flat.



G. Granite. M. Mesozoic. S. S. Silurian

1. Upper Miocene or Lower Pliocene. 2. Middle Pliocene. 3. Basaltic overflow. 4. Wash of conglomerate pebbles. 5. Upper Pliocene. 6. Pleistocene. 7. Recent.

the manganese in dendritic markings, or as if smoked, and soiling the fingers when rubbed; a white siliceous cement, sometimes coloured apple-green by silicate of iron (probably derived from the veins of green clay, mentioned before as occurring in the joints of the basalt);[1] quartzite; white, grey, and black flints and slates, the latter showing oblique lamination, and reticulated with veins of white quartz, and passing into a breccia; a greenish silico-felspathic rock or felstone, weathering yellowish-white to a depth of an inch or more, and ringing, when struck, with a metallic sound, and generally sculptured into curious forms; hard altered siliceous sandstone; schorl rock (a quartzite with nests of schorl); a peculiar hard white stratified rock, with flattened annular concretions, having depressed centres, very numerous on the bedding planes; black or smoky quartz, sometimes inclosing felspar; orthoclase in waterworn crystals; double hexagonal pyramids of quartz, occasionally rounded; bluish opaline quartz in pieces about the size of a pea, showing, when wetted, a yellow ray; amethystine quartz; silicified wood and wood opal; jasper (occurring also in the form of beans, since called by the Bingera miners "morlops"), which the miners suppose to be an unerring indication of the presence of the diamond, for what reason they could not themselves explain; agates, generally of inferior quality and colour; carnelian; chalcedony; tourmaline in rounded crystals; common corundum or adamantine spar, in flattish pieces showing distinct cleavage planes; black corundum; blue, yellow, and green sapphire, occasionally double-coloured, in flat plates and rounded crystals; olivine (?); white and brown zircons in rounded crystals and as a fine sparkling heavy sand; large quantities of brown and greenish-black rounded pieces of pleonaste; thin lenticular plates of pink and violet ruby; white, yellow, and pale-blue crystallized and rounded topaz, generally of a larger size than any of the other gems, and showing distinct cleavage planes; beryl (?); a new variety of corundum in rounded opaque grey six-sided prisms, tapering towards one end; brookite in flat plates; titanic iron, and probably chromite; magnetic iron, sometimes in quantity; and lastly a jet-black glistening vesicular variety of pleonaste, in flattish conchoidal grains, exceedingly hard, and cutting glass nearly as well as the diamond, the vesicles being filled with a magnesian clay. Wood tin occurs also rarely, and fragments of brown ferruginous wood have been detected in the cement.

The *newer* drift, derived from the above, is composed of the same contents as the *older* drift, with the addition of boulders of greenstone and basalt. Semi-angular blocks of the metamorphic rocks occur, as also the white kaolinic clay from which the magnesite already mentioned is produced. Osmiridium has been found in minute silvery scales after amalgamating the gold. A noticeable feature in this drift is the quantity of small pebbles of flesh-coloured quartz, derived, I believe, from the Carboniferous conglomerates.

[1] The pebbles from these cements have sometimes a very peculiar resinous glaze on their surfaces, which is certainly not due to friction, as the cavities are equally glazed as the exposed surfaces. It is probably siliceous.

In the drift also may occasionally, though rarely, be found some Carboniferous conglomerate pebbles. Rounded pebbles of coral (*Favosites Gothlandica*) are not uncommon; shales with *Glossopteris*, and various Upper Silurian, or Devonian fossils (*Orthis*, *Spirifer*, and Crinoidal stems), as before mentioned, together with silicified wood, have been observed in this drift in the so-called "floating reef." The *newest* drifts (upper and lower), comprising the present river-bed, and the older and deeper channels, contain pebbles, boulders, and shingle of the neighbouring sandstones, slates, calcareous grits, red flinty porphyries, felstone, Carboniferous conglomerates, quartz of all kinds, greenstone, and silicified wood. A very noticeable feature in these drifts is the prevalence of blackish quartz pebbles and grains, inclosing crystalline felspar, which are evidently derived from the granite of Aaron's Pass, on the Mudgee Road, south of the village of Cudgegong. The basalt, which might have been expected to be present, must, from its easy decomposition, have been entirely washed away, and is nowhere seen except in the immediate neighbourhood of basalt escarpments. Garnets, in minute brown rhombic dodecahedrons, with angular replacements, occur, and also cubes of oxide of iron (pseudomorphs after iron pyrites), locally termed "Devil's dice." Many diamonds were obtained from the river-bed; but in every case, only where the older drift has been discharged into the river by the miners during gold-washing operations.

The following are descriptions of the gems and other minerals, found in the diamond drifts, with the analyses of some of them by the late Professor Thomson.

Diamond.—The diamond itself is distributed through the older drift very sparingly and irregularly, and does not appear to be confined to any particular level in the drift deposit, though the lower five or six feet are generally taken out by the miners, in consequence of the certainty of finding gold in that portion. The fact of the very frequent occurrence of diamonds on the waste heaps round the mouths of the old shafts sunk for gold, is enough to suggest that the diamond may occur in the higher portions of the deposit, since the bottom layers only have been carted to the river for gold-washing. One diamond, *in situ*, occurred three feet from the bottom, imbedded in a mass of loosely cemented quartz pebbles the size of peas. As regards the weight of the diamonds, the following parcels afford a fair average :—

106	diamonds	weighed	$74\frac{1}{2}$	carats,	the largest	$1\frac{3}{5}$ carats.
81	"	"	19	"	"	$1\frac{1}{2}$ "
110	"	"	$26\frac{1}{2}$	"		
16	"	"	6	"		
700	"	"	$151\frac{1}{3}$	"		

giving an average of 0·23 carats each, or nearly one carat grain. The largest gem discovered was a colourless perfect octahedron, weighing $5\frac{5}{8}$ carats; it was found in the river, between the "Two-mile-flat" and the "Rocky ridge," at a spot where the *older* drift had been discharged in gold-washing. Another large stone, weighing $3\frac{1}{4}$ carats, was found, by a boy, lying on the sandy bed of a dry creek, running down the centre of the "Two-mile-flat." During the first five months of systematic washing, over 2,500 diamonds were discovered, and several thousands more were afterwards obtained; but, as the collectors were generally rather reticent as to their finds, the exact numbers could not be ascertained. The gems were mostly pellucid and colourless; many have a straw-yellow tint, and tints of brown, light or dark bottle-green and black are more rarely met with. One or two opaque black ones have been found, and another of a dark green colour, with the external appearance of having been polished with black lead. Black specks within the crystals were not uncommon. The specific gravity, deduced from a number of crystals, is 3·44. They all show a well-defined crystalline form, though irregularities of development are frequent. It is very rare to meet with fractured stones, and these only on cleavage planes; water-worn stones I never saw from any direct treatment of the undisturbed *older* drift. Some shapeless diamonds occur, but, if water-worn, the process has not impaired their lustre. They are never found coated superficially with any foreign matter. When dull or lustreless, an examination proved it to be caused, not by any water-wearing or incrustation, but by multitudes of minute angles and edges of structural planes, which gave a frosted appearance to the crystal. The forms met with were the octahedron, twin-octahedron, dodecahedron, tris-octahedron, and hexakis-octahedron; the two latter are often hemihedral, with curved faces, and are sometimes developed into flat triangular twins. One specimen of the deltoid dodecahedron or hemihedral triakis-octahedron was found.

The above-named curious triangular twin crystals are, according to the late Professor Thomson, derivable from the tris-octahedron. If we regard the latter as an octahedron with a low triangular pyramid on each of its faces, and out of the eight pyramids we imagine that only two, corresponding to opposite and parallel octahedral faces, are developed, on applying these two pyramids together, they would not form a closed figure, but, by twisting one 180° round, we form the triangular twin crystal; or, more simply, if we inspect a twin-octahedron, there are but two of the original triangular faces entire; these are opposite and parallel, and, by replacing these two faces by the corresponding planes of the tris-octahedron, the rest of the faces of the twin-octahedron may be obliterated, and the triangular crystal will result. The structural laminæ are very distinct in some crystals, and many of the octahedrons show these successive layers of growth in a very marked and beautiful manner. A few show indented angles, and sunk triangular depressions on their faces, having the apices of the triangles pointing to the centres of the sides of the triangles in the main crystal.

Gold.—Occurs fine, scaly, and occasionally inclosed in quartz. The quantity is variable, the average being about three pennyweights to the load of "wash dirt."

Osmiridium.—In minute silvery scales after amalgamation and retorting—only from the *newer* drift.

Metallic iron. — Hackly fragments of slightly rusted metal, evidently derived from the tools used. Analysis failed to detect any trace of nickel.

Wood tin.—Rare, and in small pieces.

Titanic acid.—Probably brookite, in flat red transparent or reddish-white translucent plates, with striated surfaces, but too worn to distinguish the crystalline form. The plates vary in thickness up to one-twelfth of an inch, and are often one-fourth of an inch across; hardness, 6; specific gravity, 4·13; composition found by analysis to be pure titanic acid, with only a minute trace of iron.

Black magnetic iron sand.—Common.

Black titaniferous iron sand.—Common.

Tourmaline-schorl.—Rolled black prisms half an inch long are common; small nests of schorl in quartz pebbles rare.

Garnet.—In minute brown icositetrahedrons, rare and only occurring in the recent river drifts.

Black vesicular pleonaste.— Occurs in small grains from one-twentieth to one-fourth of an inch in diameter, and is very abundant. It has a dull black surface, but shows a brilliant fracture. Some pieces are coated bluish grey or rusty brown; but the interior is the same in all, the external differences seeming to be the result of decomposition. It never occurs in crystals, nor shows any traces of faces, and has no cleavage; its fracture is conchoidal and jet black, with a strong vitreous lustre; hardness 8; streak grey; composition found by analysis:—

Silica (and undecomposed)	2.75
Alumina	64·29
Chromic oxide	4·62
Magnesia	21·95
Ferrous oxide	4·49
	98·10

Oxygen ratio 3·2 : 1; Specific gravity 3·77.

The mineral is amorphous and vesicular. The latter character is remarkable, and the grains do not all show it in the same degree. One variety (the least abundant) with a lustrous surface shows it best, the grains resembling a perfect cinder when seen through a lens. Several pounds weight of this mineral were obtained from each load of gravel washed, more especially from the *newer* drift.

Topaz.—In waterworn fragments, and sometimes in imperfect crystals, with terminal planes; transparent and usually white, rarely yellow or light blue. This is the largest of the associated minerals, varying in size up to half an inch in diameter.

Zircon.—In small rolled pieces, and as a fine heavy sparkling sand in abundance; transparent, brown, very pale red, or colourless. They rarely exceed one-fourth of an inch, and are mostly smaller; but are found higher up the river, and above the diamond fields, in pieces of much larger size and richer in colour.

Corundum.—

Var. (*a*). *Sapphire.*—Transparent, blue, green, yellowish, and particoloured; too small and of bad colour to be of value.

(*b*). *Adamantine spar.*—Hair-brown and black with chatoyant lustre.

(*c*). *Barklyite.*—An opaque magenta-coloured variety first discovered in Victoria and named after Sir Henry Barkly.

All the above occur in small fragments (larger higher up the river) in great abundance.

(*d*). A variety, locally termed "mouse dung," which it much resembles, is characteristic of the locality. It occurs in six-sided prisms, slightly barrel-shaped or tapering, with flat end faces; one-fourth of an inch long, and one-twentieth of an inch in diameter; bluish white, with a few dark blue spots, opaque; hardness 9; specific gravity 3·59; composition found by analysis:—

Alumina	98·57
Ferric oxide	2·25
Lime	·45
	101·27

(*e*). *Ruby.*—A transparent pink variety, found sparingly in flat grains one-tenth of an inch in diameter; its shade often passes into violet and blue; hardness 9; specific gravity 3·96; composition found by analysis:—

Alumina	97·90
Ferric oxide...	1·39
Magnesia	·63
Lime	·52
	100·44

(*f*). A few large rolled oval pebbles of corundum have also been noticed, exceeding half an inch, of a mottled dirty white and pink colour, perfectly opaque. From their low and variable specific gravity (3·21 to 3·44 and upwards) they appear to be impure massive forms of the mineral, and possess the requisite hardness. They look like jasper pebbles, and are probably what are termed "morlops" by the Bingera miners. Their specific gravity accounts for their association with the diamonds in washing off.

Quartz.—Opaque double hexagonal pyramids, one-eighth to one-fifth of an inch in diameter, are very common. Quartz pebbles occur of all sizes. The varieties comprise *agate* of poor quality, *carnelian*, *jasper*, *rock crystal*, *smoky quartz*, *amethystine quartz* (rare), and a bluish opaline variety. Fragments of grey quartz, imbedding felspar, derived from the granite of Aaron's Pass, 40 miles up the river, are common. A geode of chalcedony, having the cavity filled with quartz crystallized in rhombs, was also found.

Having thus fully described the geology of this diamond field, and seeing that the diamond occurs in an old river drift, we are led to inquire whether the diamond has been drifted, like the other minerals with which it is associated, and, if so, which of the formations—Igneous (granite, greenstone, basalt, etc.) or Sedimentary (Upper Silurian, Devonian, Carboniferous or Mesozoic)—has afforded it? or, has the diamond *grown* in the *older drift* in which it is now found?

Diamonds were first reported by the late Rev. W. B. Clarke (Southern Gold-fields of New South Wales, page 272) from the Macquarie River in 1860. On this river, at Suttor's Bar, they were worked contemporaneously with the Cudgegong, but, owing to heavy floods, little could be done. The Bingera field was reported on by Professor Liversidge in 1873 (Mines and Mineral Statistics of New South Wales, 1875, p. 104).[1] The Borah Creek (a tributary of

[1] See also, Liversidge, Quart. Journ. Geol. Soc. 1875, vol. xxxi. pp. 489-492.—R. E., jun.

the Gwydir River, New England District, New South Wales) tin and diamond mines were reported on by my late colleague, Mr. C. S. Wilkinson (Mines, etc., New South Wales, 1875, p. 79); and at Bald Hill, near Hill End, Lambaroora, diamonds were also reported on by Prof. Liversidge (Mines, etc., New South Wales, 1875, p. 115), where some tolerably large ones were found—one slightly over three carats (9·6 grains Troy), and another one and a half carats (4·5 grains Troy). The late Professor Thomson was shown some diamonds which were said to have been obtained in the sands at the mouth of the Clarence River; and the writer was shown one from a drift underlying basalt near Trunkey Creek, Tuena, Abercrombie River. In all these instances, with the exception of Borah Creek, the surrounding country is entirely Palæozoic, intersected, however, by dykes and masses of various igneous rocks.

The fact of the diamonds exhibiting structural or growth planes is, I think, sufficient to enable us to disregard the igneous rocks for their origin, unless some of these rocks (the granites and greenstones) are metamorphic. Wöhler asserted that the diamond could not have been formed at a high temperature, least of all by fusion. Brewster thought that the old conjecture, that diamonds were of vegetable origin, was confirmed by their optical properties, and analogy to amber.

The occurrence of tin with the diamond at Borah Creek, New South Wales, and at Beechworth, Victoria, both in granitic areas, indicates granite as their possible source; but tin always occurs with diamond, in small quantity, in the other districts mentioned, which are more numerous, and all in older sedimentary rock areas.

In Mines and Mineral Statistics of New South Wales, 1875, p. 79, Mr. Wilkinson states that the Borah Creek tin and diamonds occur in a newer drift, a wash from the older Miocene drift underlying the basalt, and that the entire watershed of the country is granitic. He also notices the occurrence of small black pebbles of jasper, which seem to him to indicate that the rock producing the diamond may have been entirely denuded away. On this field the diamonds average in weight about one carat grain each (the largest 5·5 carat grains), and their facets and edges are never waterworn or abraded. On page 88, speaking of diamonds and tin, Mr. Wilkinson states, "There seems but little doubt that they have been derived from the older Tertiary gravels; and this is an agreement with the observations of the late Professor Thomson and Mr. Norman Taylor on the Cudgegong diamond field." Mr. Wilkinson seems partly to have subscribed to the writer's view that the *older* drift *is* the matrix of the diamond.

In Captain Burton's "Highlands of Brazil," vol. ii. page 137, he says, "For reasons that will presently appear, it (the diamond) is evidently younger at times than the formation of gold, and it is probably still forming, and with capacity for growth." The writer failed, however, to notice the reasons that were to appear.

Professor Liversidge remarks that the Bingera diamond field is surrounded by rocks of Devonian or Carboniferous age, but that he had no fossil evidence. The diamond drift rests on argillaceous shales with interbedded conglomerates. The miners regard these conglomerates as being diamond bearing, but without any proof. He states also that he had not detected any fractured diamonds.[1]

If the diamond is derived from the Carboniferous rocks, why is it not found in the present river-bed (except where tailings have been washed into it) which abounds in Carboniferous detritus; more than one-half of the pebbles and boulders consisting of Carboniferous conglomerates? Why also is it totally absent, although carefully looked for, in close proximity to the Carboniferous rocks, as at Cudgegong, and immediately under their escarpments at Tallawang, and in all the streams of the upper sources of the river? It is rare to find a trace of the Carboniferous rocks in the *older* drift, and only occasionally in the newer, whilst they are common in the most recent river drifts. The sand in the newer drifts is probably the remains of the Hawkesbury sandstones, which overlie the Carboniferous rocks, and must at one time have had a far wider extension. The late Rev. W. B. Clarke observed that the occurrence of grains of *graphite* in the Hawkesbury rocks looks like an approach towards the diamond; and, in a letter to the writer, he says that the evidence of fossil wood must be rejected, as it is found in various formations of all ages.

If the gem-stones in the *older drift* (underlying basalt) were derived from basalt, this basalt must have been older than that now covering the drift, and there is no trace of such older basalt, if we except that capping Mount Bocoble, west of Cudgegong, which is of a totally different character to the Cudgegong flow, and at nearly 1000 feet higher elevation. We are then driven to the greenstones and granites for the origin of the gems, and here we are completely at fault.

The Broombee and Cudgegong limestones (Devonian) may have supplied the rubies, as they do not occur above the latter place, nor are topaz or diamond found there.

The gems associated with diamonds are very common in most of the river drifts of Victoria and New South Wales, but in one instance only in the former colony, at Beechworth, have diamonds been found. And, if these gems are derived from igneous or metamorphic rocks, and their presence is an indication of the diamond, how is it they are associated in one place and not in another, the surrounding circumstances being apparently the same?

Why is the *corundum* family—all the members of which, or nearly all, are as hard as the diamond, and harder than all other rocks which would be at all likely to grind down their angles—rounded and fractured, and not the diamond, which, although the hardest mineral known, is brittle and easily fractured on its cleavage planes?

[1] The cinnabar erroneously quoted by Professor Liversidge (from the article by the late Professor and the writer) as occurring at the Mudgee diamond field, does not do so. It is found in an old river drift near the village of Cudgegong, over 40 miles higher up the river, and has no connexion whatever with the diamond drifts.

Why are diamonds, if drifted, so variable in size, being often larger down the river than nearer their supposed source?

Why are diamonds, nearly always, more or less contorted from the true octahedron, forming oblique octahedrons?

Why are the diamonds, when they occur in the largest quantity, both larger and purer than when in small quantity?

Why are diamonds *locally* variable in aspect, one spot turning out straw-yellow coloured gems, another with internal black spots, and another perfectly pure?

Any answer to the above queries must of necessity lead to the conclusion that the diamonds have been formed *in situ* in the *older* drift. The writer, for his own part, believes that the so-called association of other gems with the diamond is purely accidental, that these gems occur at the bottom of the older drift, with the gold; the diamonds occurring at irregular depths above it, and their association being merely due to the miners taking out some six feet or more of the drift, and thereby bringing them together in the process of washing.

All the extracts brought forward by the late Rev. W. B. Clarke, in his Presidential Address to the Royal Society of New South Wales, in May, 1870,[1] only prove that a large amount of unreliable and unreconcilable data have been collected, which add little or nothing to our knowledge of the true matrix of the diamond; and, as to how the diamond has been formed, taking this gem as an illustration of the purest form of the element carbon, as little is known or likely to be, as there is of any of the other elementary substances. Until chemistry throws some light upon the possible modes of formation of the diamond in nature, and demonstrates the necessity of its occurrence in metamorphic rocks, it is perhaps as easy to suppose that the gem may originate in a late Tertiary drift deposit, as in the most ancient strata of a somewhat similar origin. Quartzites and quartzose conglomerates occur in Australian Tertiary deposits having as highly metamorphosed an aspect as those in the Silurian rocks. If the diamonds have been formed in the older drift, it will account for their absence in the present river-bed; on the other hand, if the diamond has been drifted from its original matrix, either it might be expected to occur in the river, where it has never yet been detected, or, its matrix has been entirely denuded away in older Pliocene or earlier times. Large areas of Carboniferous and older strata, as well as extensive tracts of Tertiary basalt, have disappeared from the river basin; and some persons have therefore proposed to assign the original position of the diamond to local and limited deposits in the demolished Palæozoic rocks.

[1] See Trans. R. Soc. N. S. Wales for 1870, pp. 1—48, "On the Discovery of the Diamond in N. S. Wales;" and *Ibid.* for 1872, pp. 1—66, "On the Natural History of the Diamond."—R. E., jun.

V.—Origin of Pipe Ore.

By J. P. Lesley, of Philadelphia.

THE following account of the discovery of an underground lake in Algeria went the rounds of the newspapers in July, 1879.

The Tlemcen *Courier* (Algeria) describes a wonderful discovery recently made at the picturesque cascades of that place. Some miners had blasted an enormous rock near the cascades, and, on removal of the débris, found it had covered a large opening into a cave, the floor of which was covered with water. Constructing a rude raft, and providing themselves with candles, the workmen sailed along this underground river, which, at a distance of 60 mètres, was found to emerge into a large lake of limpid water. The roof of the cavern was very high, and covered with stalactites, the brilliant colours of which sparkled under the light of the candles. Continuing their course, the workmen had, at certain places, to navigate their craft between the stalactites, which, meeting stalagmites from the bed of the lake, formed enormous columns, which looked as if they had been made expressly to sustain the enormous arches. They thus reached the extremity of the lake, where they noticed a large channel extending toward the south, into which water quietly made its way. This is supposed to be a wide fissure which has baffled exploration hitherto at Sebdon, and which connects the cascades with that locality, and thus with the mysterious sources of the Tafna. It is possible that here they have found an immense natural basin, supplied by powerful sources, and sending a part of its waters towards the lake, while the rest goes to Sebdon. The workmen estimated the distance underground traversed by them at three kilomètres, and the breadth of the lake at two. They brought out with them a quantity of fish, which swarmed round the raft, and which were found to be blind.

Whatever exaggerations may have been indulged in by the reporter of the discovery described above, I think that it is worthy of the thoughtful attention of geologists, for several reasons :—

1. It offers a rational solution of the problem how the roofs of wide caverns in limestone regions have been, and still are, supported.

2. It supports the views which I have repeatedly published respecting the prime agent for determining the topography of the earth's surface, viz. the dissolution of the limestone formations, the letting down of the over-rocks, and the gradual withdrawal of the outcrops from each other on opposite sides of anticlinals; and in steps determined by the limestone formations.

3. It clears up the chief obstacle to a rational theory of the genesis of our pipe-ore deposits; and this is why I invite to it the attention of my fellow-geologists in Great Britain, hoping to get from them expressions of assent or dissent.

In the larger limonite mines of Pennsylvania, botryoidal ore masses occur, the origin of which has never been explained. The older mines are now open quarries, hundreds of yards long and wide, and from 50 to 150 feet deep; of irregular shapes; surrounded by walls of massive limestone; and floored with mud and standing water. They are vast pots in the Lower Silurian or Siluro-Cambrian Magnesian Limestone formation, No. II. of our old survey, the Calciferous and Chazy formations of the New York and Canada reports. Many of them have been excavated to their beds; all the iron ore removed, and the mine abandoned. Others still hold unknown quantities of limonite beneath the mud floor, as shown by trial bore-holes.

The clay which filled (and partly still fills) such a mine is in some cases nothing but the decomposed limestone rock in place, or rather the intercalated impure limestone layers reduced to clay. In other cases the clay has been brought from the neighbourhood into the pot with, or without, lignite. In all cases it is rudely stratified; some of the layers being full of shot ore and ball ore; others being nearly pure white, yellow, or black clay. Usually the quantity of ore increases with the depth; solid floors of ore occur; or the bottom of the pot is filled with solid ore.

Up through this ore-bearing clay-mass rise steeples of pipe ore, the tops of which are struck by the miners at various distances beneath the sod. Some of them projected from the forest-covered soil, as humps of pipe-ore, and led to the discovery of the mine; others were not encountered until the quarry floor had been sunk 10, 20, or 50 feet. But in all cases the pipe-ore mass is a steeple, enlarging downwards with ever-broadening base, and standing finally on the limestone foundation at the bottom of the clay. Oftentimes several steeples unite their bases, like a clump of trees. Some of them have been 100 feet high, and proportionately wide at the base.

The common idea has been that they are concretionary masses, derived from the moist iron-bearing clays.

I have long held that all these limonite deposits have been made in caverns. I now suggest that the broader caverns had their roofs supported (for a time) by masses of stalactite (now removed by erosion) and stalagmite; and that the stalagmite piers have been metasomatized into pipe ore, and remain standing in the surrounding clay.

1008, Clinton-street, Philadelphia,
July 29, 1878.

NOTICES OF MEMOIRS.

Ammonites of the Mediterranean and Juvavian Trias. By Dr. Ed. von Mojsisovics.

[Proceed. Imper. Geol. Instit. Vienna, April 1, 1879.]
(Communicated by Count Marschall, F.C.G.S., etc., etc.)

General Considerations.

The forms united in one genus must agree in their least variable characters (disposition and form of the lobes, form and structure of the shell, length of the body-chamber, and form of the margin of the aperture). In continuous genetic series, the limits between the primary genus and those descending (?) from it must necessarily be traced somewhat arbitrarily. Forms or groups of forms, of sporadic occurrence, not possessing indubitable characters of known genera, are generally best considered as constituting independent genera. Isolated forms, notably aberrant in one direction from the generic type, are provisionally ranked among the primary genera.

Arcestidæ.

The genera *Cladiscites*, *Joannites*, and *Sphingites* being eliminated, the genus *Arcestes*, Suess, comprises the groups of *Extra-labiati*, *Sub-labiati*, *Bi-carinati*, *Coloni*, *Intus-labiati*, *Galeati*, and *Sub-umbilicati;* all of them characterized by more or less modified body-chambers of the full-grown individuals and by a contraction of the umbilicus, frequently occluded by a callosity.

Sphingites, Mojs.—This genus comprises the group of Co-angustati, characterized by a widely open umbilicus, prominent ridges, and strictures in the shell of the whorls, including the inhabited chamber, and coarse wrinkled striations. *Cladiscites*, Mojs.—The *Tornati* and *Multilobati* bear a number of characters different from those of the typical *Arcestes.* The constantly closed whorls, of nearly quadrangular transverse section, show neither internal nor external ridges and keep their form even in the last whorl of full-grown individuals. Their lobes offer a peculiar structure. The projection of the preceding whorl coincides with the first auxiliary lobe, not, as in all other *Arcestidæ*, with the second lateral lobe. This is an approximation to the distribution of the lobes of the *Pinacoceratidæ*, and becomes still more conspicuous in *Cladiscites sub-tornatus* by the deepening of the second lateral lobe. Prof. Quenstedt was the first who noticed the peculiar structure of the anti-siphonal lobe with its two many-jointed branches.

Joannites, Mojs.—Like the *Tornati*, the *Cymbiformes* are to be generically separated, as they agree in every respect with *Arcestes* except in the form of their lobes, which is the same as in the genus *Cladiscites*. They are characterized by their arcuate lobe-line.

Didymites, Mojs.

Lobites, Mojs. = *Clydonites*, Laube, = *Coroceras*, Hyatt.

AMALTHEIDÆ.

Ptychites, Mojs.

Amaltheus, Montf.—Triassic forms, standing next to the group of *Fissi-lobati*. The *Amalthei* comprise a number of evidently distinct groups, which may be generically separated.

PINACOCERATIDÆ.

Pinacoceras, Mojs.

Megaphyllites, Mojs.—The group of *Megaphylli*, Beyr. (Type: *Ammonites Tarbas*), differ from *Pinacoceras* in the form of their lobes.

Sageceras, Mojs.

Carnites, Moys.—Comprises *Carnites floridus*, Wulf., *Carn. raristriatus*, Hauer, and a nondescript species from the Muschelkalk. Very probably this genus is to be connected with *Ceratites Hedenstrœmi*, Keys., or with a form nearly allied to it. The form of the lobes distinguishes *Carnites* from *Pinacoceras*.

Norites, Mojs.—The Triassic species are—*Norites Caprilensis*, Mojs., and *Nor. Gondola*, Mojs. Shell similar to *Sageceras*. Rugose stratum linear. One adventitious saddle of less height than the first primary saddle. Saddles narrow, high, rounded above. Lobes with few indentures, first chief lobe divided by a large indenture. More ancient forms from the sandstones of Artinsk, described by de

Verneuil and Karpinsky, such as *Goniatites cyclobus, Gon. post-carbonnarius,* and *Gon. præ-permicus,* may be very closely related to *Norites.*

LYTOCERATIDÆ.

Monophyllites.—Lytoceras sphærophyllum and *Lyt. Morloti* are to constitute a genus distinct from *Lytoceras* on account of the peculiar form of their lobes.

Phylloceras, Suess.

AEGOCERATIDÆ.

Aegoceras, Waag.—This generic denomination may provisionally be reserved for a number of forms from the Mediterranean Muschelkalk, and further researches must decide how far it is to be superseded by that of *Psiloceras,* Hyatt.

TROPITIDÆ.

This family is nearly related to the *Arcestidæ,* and distinguished by a well-developed system of sculpture, and by the length of its inhabited chamber, extending over a whole whorl. The rugose stratum has only been observed in the genus *Halorites.*

Tropites, Moys.—This genus includes the manifold forms allied to *Trop. sub-bullatus,* Hauer; *Trop. Jokelyi,* Hauer; and *Trop. costatus.* Some of these forms show spiral undulated lines similar to those of some *Goniatites,* whose external form reminds us of *Tropites.*

Entomoceras, Hyatt.—The American type of this genus, *Entom. Laubei,* Meek, stands extremely near to the group of *Ammonites Sandlingensis,* Hauer (*Entomoc. Theron,* Dittm., etc.), which group is nearly allied to *Tropites.* It is characterized by a flat compressed shape, a high cultriform carina, aberrant lobes, and, in some cases, by the presence of a number of spines, reminding us of *Trachyceras.* Length of the inhabited chamber still unknown.

Halorites, Mojs.—Includes the group of *Halorites Ramsaueri,* Quenst., characterized by a body-chamber and mode of growth similar to those of *Arcestes,* sculpture like strings of pearls on the inner whorls, and high saddles with many lateral branches. Lateral lobes reduced. Whorl of the inhabited chamber different in shape and sculpture from the inner whorls. Margin of the mouth with a slight stricture. Aberrant forms: *Hal. semi-plicatus,* Hauer; *Hal. decrescens,* Hau.; *Hal. semi-globosus,* Hau.; and *Ammonites Medleyanus,* Stol.

Juvavites, Mojs.—Comprises the groups of *Juv. Ehrlichi,* Hau.; and *Juv. alterni-plicatus,* Hau. Near to *Halorites;* different from this genus by the similitude of the whorl of the inhabited chamber with the inner whorls, and by the lobes being less slitted. Periodical constrictions of the shell are frequent.

Distichites, Mojs.—Convex portion with a channel-like depression in the middle, frequently with smooth carinæ along the margins. Inner whorls, save the double carina, similar in sculpture to those of *Tropites Jokelyi.* Outer whorls gradually flattening; the outer range of spines advancing to the middle of the sides, where also the ribs increase in number by bifurcation and intercalation. Inhabited chamber extending beyond a whorl. Lobes similar to those of

Sagenites. Generic type, *Dist. Celticus*, Mojs. Only a few species, such as *Dist. pseudo-aries*, Hau., and *Dist. Harpalus*, Dtm., are as yet described.

CERATITIDÆ.

This family appears first in the Permians, and reaches, under manifold modifications of form, upwards into the Lower Carnian deposits. The Indian and Armenian forms, described by MM. Koninck, Waagen, and Abich, stand in evident contrast with those typical of our "Werfen" beds, and of our Muschelkalk. The *Tirolites* from the Werfen beds represent a far lower stage of development than those of India and Armenia, so that, were the age of the deposits in which they appear not sufficiently ascertained, they might be regarded as having belonged to a far remoter period. The types of the Asiatic Permian forms reach far upwards into the Trias, as proved by *Hungarites scaphitiformis*, Hau., a sporadic "colonist" in the Norian Hallstatt Limestones, nearly resembling *Ceratites tropitus*, Abich, in its outward form, as in the details of its lobe-line. MM. Grünewaldt and Karpinsky have described two species from the Artinsk Sandstones: *Goniatites Artiensis* and *Sageceras Sakmaræ*, whose lobes are still unknown, but whose form and sculpture strongly remind us of the typical forms of *Trachyceras* from the Norian and Carnian horizons.

Tirolites.—The typical forms are: *Tir. Idrianus*, Hauer, *Tir. Dalmatinus*, Hau., and *Tir. Muchianus*, Hau. The genus is characterized by a simple lobe-line, with entire margin, as that of *Nautilus*. The non-dentated, large, lateral lobe is followed by a broad and flat saddle, sinking gradually with a slightly undulated bend towards the suture. Another lateral lobe is but slightly marked. The projection of the preceding coincides with the large lateral saddle. In the group of *Tir. Cassianus*, these forms are associated with some others having an incipient denticulation of the lobes and distinct second lateral lobe. The convex portion is smooth, or somewhat flattened; the sides are smooth, or covered with straight radially disposed folds, frequently ending in strong hollow spines on the margin of the convex portion. *Tirolites* is chiefly developed in the Alpine "Werfen" strata. After a long interval of time, the genus re-appears, again isolatedly, in the genuine "St.-Cassian" strata (*Tirolites spurius*, Mstr. = *Clydonites Friesei*, Laube, non Mstr.), and another, as yet unnamed form, belonging to the series of *Ammonites Cassianus*.

Ceratites, de Haan (*Haaniceras*, Bayle (?), *Gymnotoceras*, Hyatt). —Besides *Ceratites Liccanus*, Hauer (very nearly allied to the Siberian species *Cerat. Middendorfi*, Keys.), another species, standing next to the group of *Tirolites Cassianus*, is met with in the "Werfen" strata. The same affinity appears in *Cerat. Smiriagini*, Auerbach, and in *Ceratites Bogdoanus*, Buch, both from the Bogdo Hills in the Steppe of Astrachan. In some of these transitional forms (*Cerat. Liccanus*, *Cerat. Smiriagini*) the second lateral saddle is wanting, so that the projection of the precedent whorls falls on the umbilical side of the large lateral saddle. A Siberian form, differing from *Cerat. Eichwaldi*, Keys., by its rounded and smooth convex portion, may be considered as a connecting form between *Ceratites* and *Tirolites.* The genus *Ceratites*, as adopted here, nearly coincides with the group *Nodosi*, Beyrich. The convex portion is constantly without sculptures, smooth, convex or flattened (in one series of forms with an indistinct medial carina). The sides are covered with moderately curved ribs or folds, multiplied by bifurcations or intercalations, and frequently adorned by umbilical, medial, and marginal spines or teeth. The number of knotted spirals varies between 0 and 3. The anti-siphonal lobe is double-pointed. The *Ceratites* of the German Muschelkalk are strikingly discrepant from the Mediterranean types by the shallowness of their lobes, possibly in consequence of anomalous proportions of the salt held in solution by the old German Sea, in which the Muschelkalk was deposited.

In *Cerat. Khanikoffi*, Opp., an Indian species, the notch of the lobe-line extends over the tops of the saddles.

Balatonites, Mojs.—This genus comprises the series of forms of *Balat. Balatonicus*, Moys., *Balat. euryomphalus*, Ben., and *Balat. Pragensis*, together with the Central-European form *Balat. Ottonis*, Buch. Lobes like those of *Ceratites;* anti-siphonal lobe unknown. Convex portion with a range of knobs running over its centre, in some cases taking the form of a carina by confluence of the knobs. Ribs numerous, constantly with umbilical and marginal spines, frequently with one or more intermediate ranges of knobs. One form from the Muschelkalk has on each side seven ranges of knobs, besides the row on the convex portion.

Acrochordites, Hyatt.—Only one very rare Mediterranean form from the Upper Muschelkalk is connected with *Acroch. Hyatti*, Meek, the American type of this genus, characterized by ribs, passing over the convex portion, and alternatingly confluent by three and three into a large knob on the umbilical margin, and other ribs, simply terminating at the same marginal lobes as those of *Ceratites.* Certain Mediterranean forms with continuous sculptures over the whole convex portion, without any knobs, or with a number of small spirals of knobs, may be conveniently ranked among this genus, which seems to be very closely allied to *Balatonites.* Possibly *Ammonites spinescens*, Hauer, may find its place in it.

Hungarites, Moys.—Narrow, fold-like ribs, high median carina; lobes like those of *Ceratites.* Possibly *Ammonites scaphitiformis*, Hauer, so similar to *Cerat. tropitus*, a Permian form from the Araxes defile, may rank in this genus. If there be a real connexion between the Alpine Triassic forms and the Permian species from Armenia, it would be a proof of genetic difference between the preceding and the coeval European forms.

Arpadites, Moys.—A limited, well-characterized group, represented in the Mediterranean province by *Arp. Arpadis*, Mojs., *Arp. Szabœi*, Boeckh, *Arp. Manzonii*, Ben., *Arp. Achelous*, Mstr., *Arp. brevi-costatus*, Klpst., *Arp. sulcifer*, Mstr., *Arp. Rueppeli*, Klpst., *Arp. Sesostris*, Laube, *Arp. Hirschi*, Laube, and several new forms;—in the Juvavian province by the groups of *Arp. Hœrnesi*, Hauer, and *Arp. Laubei*, Mojs. (*Arp. Rueppeli*, Hauer). The genus is characterized by a deep furrow in the centre of the convex portion, and a long one-pointed antisiphonal lobe. This furrow is frequently limited by smooth or knobly carinæ. In some forms the ribs end in a thickening near the furrow. A number of dichotomous or simple ribs, all of them beginning at umbilical knobs, cover the sides, on which there are also rows of knobs. The forms of higher geological age have high saddles, with entire margins; in others of less age, from the "St.-Cassian" strata, the notch extends over the heads of the saddles.

In *Arp. modestus*, an aberrant form, standing next to *Arp. Laubei*, the ribs unite over the convex portion.

Trachyceras, Laube.—The sculpture extends without interruption as far as on the convex portion, in the centre of which it is always interrupted by a narrow interval, close to which the Mediterranean forms show constantly one or more ranges of spines. In the Juvavian forms, minute notches at the ends of the ribs (see *Trachyc. bi-crenatum*, Hauer) or notched carinæ are of more frequent occurrence. Spirals of spines, of variable number in the different series of forms, appear on the inflected, bifurcated, or intercalated ribs. These spirals are more numerous on the series of less remote geological age. In some cases, all spines, except those of the characteristic ranges on the convex portion, are wanting. The lobes in forms of more remote geological age are quite concordant with those of *Ceratites*; in those geologically less ancient, Professors Quenstedt and Laube have first noticed the digitiform notches extending over the saddles, and the denticulation of the lobes increasing in depth.

Heraclites, Mojs.—A limited series of forms in the Norian strata of the Juvavian Province, with intermediate forms, connecting *Her. Poeschli*, Hauer, with *Her. robustus*, Hauer. Body-chamber very short, about half of a whorl. Strong, in some cases inflated, ribs on the sides. Convex portion flattened, traversed by two delicate, filiform, spiral lines, sometimes with nodules at the points where they run across the ribs. *Her. robustus* loses every trace of sculpture on the convex portion as it advances in age. Sculpture is likewise wanting in some forms of less remote geological age, as *Her. foliaceus*, Dtm. The lobes are characterized by a few irregular deep sections, hanging far downwards — here *Her. quadrangulus*, Hauer.

Sagenites, Mojs.—The known forms, belonging to this genus, are—*Sag. reticulatus*, Hauer, *Sag. Giebeli*, Hauer, and *Sag. inermis*, Hauer. In the typical forms the sculpture passes without interruption over the vaulted convex portion, which sinks gradually into the lateral portion; in some aberrant forms there is an interruption in the centre of the convex portion (as in *Ceratites*) and the narrow, canaliform, unsculptured band is accompanied by nodular incrassations. The numerous, delicate, pliciform, transversal ribs are crossed by a system of more or less undulated spiral lines, lying very close to each other. Umbilicus narrow. Occasionally the shell is ornamented here and there with broad obtuse knobs. Body-chamber half to three-quarters of the whorl in length. Type of the lobes aberrant

TABULAR CONSPECTUS OF THE VERTICAL DISTRIBUTION OF THE TRIASSIC AMMONITES.

				MEDITERRANEAN PROVINCE.				JUVAVIAN PROVINCE.						
	Zone of Ammonites Cassianus.	*Z. of Ceratites bi-nodosus and Balatonites Balatonicus.*	*Z. of Ceratites tri-nodosus.*	*Z. of Trachyceras Curionii and Trachyceras Reitzi.*	*Z. of Trachyc. Archelai and Daonella Lommeli.*	*Z. of Trachyceras Aon.*	*Zone of Trachyc. aonoides.*	*Z. of Choristoceras Haueri.*	*Zone of Pinacoceras Metternichi and Arcestes gigantogaleatus.*	*Z. of Pinacoceras Parma and Didymites globosus.*	*Z. of Cladiscites ruber.*	*Z. of Didymites tectus.*	*Z. of Tropites sub-bullatus.*	*Z. of Trachyceras aonoides.*
Tirolites . . .	—	.	.	.	.	—	.	.	.	.	.	.	.	.
Ceratites . . .	—	—	—	—	—	—	.	.	.	.	.	.	.	.
Norites . . .	—	—	—	.	.	.	.	.	.	.	.	.	.	.
Balatonites . .	.	—	—	—	—	.	.	.	.	.	.	.	.	.
Hungarites . .	.	.	.	—	.	.	.	.	.	—	.	.	.	.
Trachyceras . .	.	.	.	—	—	—	—	.	—	—	—	—	—	—
Arpadites . . .	.	.	.	.	—	—	.	.	.	—	.	.	.	.
Acrochordiceras .	.	—	—	.	.	.	.	.	.	.	?	.	.	.
Aegoceras . . .	.	—	—	.	.	.	.	.	.	.	.	.	.	.
Amaltheus . .	.	.	—	.	.	.	.	.	.	.	.	.	.	.
Ptychites . . .	.	—	—	—	—	.	.	.	.	.	.	.	.	.
Carnites . .	.	.	—	.	.	.	—	.	.	—	.	.	.	—
Pinacoceras . .	.	.	—	.	—	—	.	—	—	—	—	—	—	—
Megaphyllites .	.	.	—	—	—	—	—	—	—	—	—	—	—	—
Sageceras . . .	.	.	—	—	—	—	—	.	.	.	.	.	.	.
Monophyllites .	.	—	—	—	—	—	—	.	.	.	.	.	.	—
Phylloceras . .	.	.	.	.	.	.	.	—	—	—	—	—	—	.
Arcestes . . .	.	—	—	—	—	—	—	—	—	—	—	—	—	—
Sphingites . . .	.	.	.	.	.	—	.	.	.	.	.	.	.	—
Cladiscites . . .	.	.	.	.	.	—	.	—	—	—	—	—	—	—
Joannites . . .	.	.	.	.	.	—	—	.	.	.	.	.	.	—
Didymites . .	.	.	.	.	.	.	.	.	.	—	.	—	.	.
Lobites . . .	.	.	.	.	—	—	.	.	.	.	.	.	—	—
Tropites . . .	.	.	.	.	.	.	.	.	—	—	—	.	—	—
Entomoceras . .	.	.	.	.	.	.	.	.	.	.	.	.	—	—
Distichites . .	.	.	.	.	.	.	.	.	.	—	—	—	.	—
Sagenites . . .	.	.	.	.	.	.	.	.	—	—	—	—	—	—
Heraclites . .	.	.	.	.	.	.	.	.	.	—	.	.	—	.
Clydonites . . .	.	.	.	.	.	.	.	.	.	—	.	.	—	.
Choristoceras . .	.	.	.	.	—	—	.	—	—	—	.	.	.	—
Helictites . . .	.	.	.	.	.	.	.	.	.	.	.	—	—	.
Badiotites . .	.	.	.	.	.	—	.	.	.	.	.	.	.	.
Cochloceras . .	.	.	.	.	.	.	.	—	—	.	.	.	.	.
Rhabdoceras . .	.	.	.	.	.	.	.	.	—	.	.	.	—	.

from other *Ceratitidæ*. Broad high saddle-trunks, from which depart divided leaf-like branches. Similar branches rise from the bases of the lobes. Auxiliary lobes uncommonly small.

CLYDONITIDAE.

Clydonites, Hauer.—Generic type: *Clyd. decoratus*, Hauer. Evolute whorls beset with thronged, irregularly granulated, small ribs, uniting over the convex portion. Lobe-line with entire margin, undulated.

The high external saddle followed by a lower lateral one. *Clyd. modicus*, Dtm., possibly belongs to this genus.

Choristoceras, Hauer.—Generic type: *Chor. Marshi*, Hauer, with two-pointed first lateral lobe. Next to it stand several forms with entire-margined, rounded, first lateral lobe. Evolute whorls, free in adult individuals of certain forms, with simple straight ribs, interrupted on the convex portion, except in old individuals of certain forms, whose convex portion becomes somewhat flattened or depressed. Knobs, disposed in spirals, on the depressed or unsculptured part of the convex portion. In the whole six lobes, the deeply descending one-pointed anti-siphonal lobe particularly remarkable. *Chor. Marshi*, Hauer, *Chor. Haueri*, Moys., *Chor. rectangulare*, Hauer, and *Chor. Buchi* (*Klipsteinianum*, Laube) rank among this genus.

Helictites, Mojs.—Whorls evolute, with strong straight ribs, running without interruption over the convex portion. Lobe-line simply undulated, with minute notches, scarcely perceptible by the unaided eye. Species: *Hel. geniculatus*, Hauer, *Hel. Henseli*, Opp., *Hel. nasturtium*, Dtm.

Badiotites.—The St.-Cassian forms — *Ammon. Eryx*, Mstr., and *Ammon. glaucus*, Mstr., characterized by a narrow or keel-like pointed convex portion, and by falciform ribs, are morphologically so discrepant from *Choristoceras* that they must constitute an independent genus. Lobes entire-margined, undulated; anti-siphonal lobe long, one-pointed.

Rhabdoceras, Hauer.

Cochloceras, Hauer.

REVIEWS.

I. — United States Geological Exploration of the Fortieth Parallel. By Clarence King, U. S. Geologist. Illustrated by 28 Plates and 12 Analytical Geological Maps. (Washington, 1878.)

THIS fine work forms the first volume (although the last published) of the Report of the Geological Exploration of the Fortieth Parallel, under the direction of Clarence King, its subject being the "Systematic Geology" of that region. The Exploration has covered a belt of country about 100 miles wide from N. to S., and 800 miles long, extending from the eastern foot of the Rocky Mountains to the Sierra Nevada of California, or almost across the Cordilleras where they are the broadest. Assisted by an ardent and untiring corps (including A. Hague, S. F. Emmons, and others) Mr. King has endeavoured to work out the continuous geology of this almost unexplored gap connecting it, as far as possible, with the territory surveyed by Whitney on the one hand, and with Hayden's field on the other.

The purpose of this volume is to present a brief systematic account of the data collected, and the inductions deducible therefrom, so that the arrangement is chronological, beginning with the deposits of

Archæan time and proceeding without break through the entire series to the Quaternary. The first chapter contains the leading geographic features of the area, which, however, are more fully treated of in the second volume. The second to the sixth chapters contain a detailed account of the Archæan, Palæozoic, Mesozoic, and Cainozoic rocks, the seventh chapter comprising the history of the Tertiary volcanic rocks.

The characters of the Archæan rocks are treated of under the different localities where they are exposed; these rocks are considered to attain a maximum thickness of 50,000 feet, and comprise the Laurentian—consisting of red orthoclase granite, mica gneisses and schists, with deposits of ilmenite and graphite, and the Huronian—composed of plagioclase-hornblende granites, diorite-gneisses, argillites, limestones and quartzites. Between the rocks referred to Laurentian and Huronian ages, there is a characteristic difference in the intensity of the metamorphism which has taken place and also in the obliteration of original structure and in the increase in thickness, when considered in relation to depth. The lowest Laurentian aplitic granitoid bodies of the Laramie Hills are the heaviest beds and the most changed from their original sedimentary condition; the higher Huronian group of gneisses, quartzites, conglomerates, dolomites and argillites are at once the most thinly-bedded and the least metamorphosed.

The granites are divided into four groups:—1. With muscovite; 2. With little or no plagioclase and biotite; or 3. With biotite and hornblende; and a 4th type more complex than the others, containing a high per-centage of biotite, with an equal proportion of hornblende, the plagioclase often equal, or sometimes exceeding in quantity the orthoclase and titanite; the muscovite type being the oldest, and the dioritoid variety being the youngest. These granites and the crystalline schists are pre-Cambrian.

The section (p. 112) on the genesis of granite and crystalline schists contains some points which of late years have occupied the attention of geologists, and embodies the author's views as to their comparative origin.

In alluding to Dr. Sterry Hunt's theory, that early magnesian silicates are chemical precipitates from the acid ocean of their period, Mr. King sees no reason to seek for a different origin for the magnesian silicates from that of the commoner aluminous minerals, and so far as the gneisses and crystalline schists are concerned, he is led to give in a complete adhesion to the hypothesis of diagenesis for the anhydrous silicates, and of subsequent pseudomorphism for the hydrous magnesian rocks.

"In the crystalline schists and gneisses are found identically the same minerals which characterize the granites. The characteristic features of the schists are, the parallel-bedded arrangement, the strict retention of chemical materials in their original zones, and the intercalation of beds made of simple materials, like quartzites and limestones. The sole difference seems to be that granite is often demonstrably a plastic intrusion, and possesses no parallel arrangement of minerals, its various components lying more or less evenly distributed throughout the mass." With regard to the genesis of granite, the author supposes, were the chief factor to be tangential—or, as he terms it, orographical pressure, there must of necessity be all the transitions from a uniform homogeneous granite down to those rocks in which radial or gravitation has produced the ordinary bedded schists.

The Palæozoic rocks, which are everywhere unconformable to the underlying Archæan, are strictly conformable from the lowest Cambrian beds to the top of the Upper Coal-measure Limestone. Slightly developed in the Rocky Mountain system, not over 1,000 feet in thickness, they thicken out westward, as in the Wahsatch, to more than 30,000 feet, and about 40,000 feet at the extreme western Palæozoic limit. In the whole Palæozoic section there are 18,000 feet of siliceous sediment, 13,000 feet of limestone, and about 1,400 feet of slates and shales.

"The general absence throughout the Coal-measure horizons of beds of coal, and the conspicuous absence of shallow-water deposits (with the exception of some conglomerates), indicate that the whole great Palæozoic series was from the first received on the bed of a deep ocean." Within the Palæozoic series of this region there are no considerable passages of metamorphism.

Directly overlying the Palæozoic limestones are the well-known Rocky Mountain red-beds, which have been generally assigned to the Triassic age. The Trias beds are succeeded conformably by the Jurassic and Cretaceous groups, the exposures of which within the Fortieth Parallel are clearly shown in Map III. (p. 356). Owing to the widespread but unequal mechanical disturbance at the close of the Palæozoic period, the physical features of the old land area were considerably modified, so that the Trias-Jura series were formed in two separated seas, an eastern and western, differing in depth and in the nature of their sediments (p. 537).

Between the Cretaceous and Jurassic there is absolute conformity. The former represented a period of comparative calm, so far as orographic disturbances go, although it was characterized by subsidences, but so general and gradual as to leave no traces of their mode of operation, except the succession of conglomerates and tiers of coal-beds.

The Cretaceous group in descending order consists of—1. The Laramie or the Lignite group of Hayden, 1,500 to 5,000 feet. 2. Fox Hill group, 3,000 to 4,000 feet. 3. Colorado group, equal to Fort Benton, Niobrara and Fort Pierre groups of Meek and Hayden, 800 to 2,000 feet. 4. Dakota group, 300 feet.

With regard to the position of the upper member of this series (the Laramie), considerable difference of opinion now exists, so that, "aside from the Taconic system, no single geological feature in all America has ever given rise to a more extended controversy than the true assignment of the age of this group."

Mr. Clarence King discusses the position of the Laramie group, the geological horizon of which has been referred by Dr. Hayden and others (based on the plant-remains) to the Tertiary, or considered as a transition member between the Cretaceous and Tertiary. Although containing the facies of a Tertiary flora, this is associated with Dinosaurian reptiles characteristic of Mesozoic age, which, together with a period of immense disturbance at the close of the Laramie beds and complete nonconformity of the overlying series of purely freshwater shale, should constitute a division between the Mesozoic and Tertiary. "It will be seen," says the author, "that the stratigraphical break, with its unmistakable Eocene facies at the base of the one group, and the Dinosaurian reptiles at the close of the other, marks the period of nonconformity as distinctly at the close of the Cretaceous."

The fauna up to the base of the Laramie is strictly marine. The Laramie itself carries the remains of an estuarine or brackish water life, associated with strictly Mesozoic saurians.

With the close of the Cretaceous the conformable series of marine and estuarine deposits came to an end, and was immediately followed by one of the most important orographical movements of the whole Cordilleran history. The most important result of this post-Cretaceous movement was the elevation of the whole interior of the continent and the complete extinction of the inter-American Mediterranean Ocean.

From the date of this movement no marine waters have ever invaded the middle Cordilleras, and the subsequent strata are all of lacustrine origin. The Eocene of the Fortieth Parallel region was a period of four lakes, whose deposits—unconformable among themselves—amount to 10,000 feet, and are characterized by an abundant series of vertebrate life. At the close of the Eocene an important orographical movement took place by which the province of the northern Great Plains, and a long narrow tract lying on the eastern base of the Sierra Nevada and the present Cascade Range became depressed and received the drainage of the surrounding countries, forming two extended Miocene lakes. The deposits of the westernmost lake are chiefly the tuffs and re-arranged ejecta of volcanic eruption; the deposits of the plains are the simple detritus from the surrounding lands.

Another orographical movement followed the close of the Miocene, affecting differently the areas of the western and eastern lakes, so that the Pliocene opened with two enormous lakes, one covering the basin country of Utah, Nevada, Idaho, and eastern Oregon, the other occupying the province of the plains. Both of these Pliocene lakes, as do the Miocene, contain the remains of rich faunæ. The extent of the Tertiary exposures are seen in Map IV., and the sequence of the Tertiary lakes at p. 458. The close of the Pliocene period was signalized by another considerable movement, which affected differently the area occupied by its sediments, and was followed by the varied series of deposits of the Quaternary age, described in Section V. (pp. 459—529), which is full of interesting matter, not only as relating to glacial phenomena and the lake deposits of the period, but also as to the structure and origin of the remarkable gorges or cañons, which are wholly within this period.

"During the Quaternary period most modern mountain topography received its present form. Most, if not all, of the sharp cañons were carved, and the mechanical results of that erosion are seen in the great accumulations of subaerial gravel in regions of interior drainage like the Great Basin, and in deposits of unknown thickness classed as Lower Quaternary, which gathered on the beds of the Quaternary lakes."

It has therefore been the object of Mr. King in Chapters II. to V. to give a general account of such facts as seemed to be necessary to a comprehension of the sequences and subdivisions of sedimentary geology. In the 120,000 feet of these accumulations, the grander divisions of the Archæan or Azoic, Palæozoic, Mesozoic, are distinctly outlined by divisional periods of marked unconformity. From the first of the Cambrian age to the present day every important interval of time is recorded in the abundant gathering of sediments, which are with singular fullness characterized by appropriate and typical life forms. Of the 77,000 feet of beds from the Lower Cambrian to the close of the Tertiary, nearly 20,000 feet are limestone, the rest is purely detrital, the limestones, however, throughout the entire Cretaceous and Tertiary are all fragmentary, and are simply the pulverized sediments which were washed down from the neighbouring limestone formations.

Chapter VII. comprises the more important facts accumulated during the Exploration relative to the Tertiary volcanic rocks as to sequence, geological dates, modes of occurrence, reciprocal relations, and petrographic distinctions. The latter subject has also been fully treated in the admirable and instructive memoir by Prof. Zirkel, forming vol. vi. of the series. The material is classed under three groups: 1st. The detailed occurrence of species; 2nd. The relations of each rock to the orographical actions which brought it to the surface, and the succession of each species; 3rd. The origin of igneous fusion and the genesis and petrological classification of volcanic rocks.

The close of the Jurassic age was characterized in Nevada and Utah by scattered eruptions of middle-age eruptive rocks, including diorite, diabase, and porphyries; with a doubtful exception, all the other volcanic series are referable directly to the Tertiary. The natural sequence of the volcanic rocks observed in the Fortieth Parallel corroborates the previous researches of Richthofen, which is as follows: 1. Propylites; 2. Andesites; 3. Trachytes; 4. Rhyolites; 5. Basalts. The acidic products are enormously in excess of the basic products (as shown in Map VII.), and almost equally in excess of rocks of mean constitution, as the hornblende propylites, andesites and trachytes. Taken as a whole, Rhyolite is the predominating volcanic rock of this field, and considerably exceeds the Basalts, which rank next in territorial area. These two families, at once the most acidic and most basic, cover together ten times as many square miles as all the rest of the volcanic series combined.

The section on the fusion and genesis of volcanic rocks (pp. 696–725), and their classification, is well worthy of the attention of those interested in this branch of geology, especially as regards the author's view of volcanic fusion.

After alluding to the various hypotheses on this subject, the author says:—"Suppose above the temperature of fusion is a column of thirty miles of rock, and suppose three miles are rapidly removed by erosion. The position of the *couche* of temperature of fusion will constantly tend to retire towards the centre of the earth. If it retires at the same rate as erosion, the effect of pressure on the *couche* of the temperature of fusion will remain the same; but if the rate of erosion and consequent removal of pressure is greater than that of the recession of the *couche* of temperature, plus that of general secular recession, the effect, it would seem, must be to create a local fusion."

The orography of the region forms the subject of the eighth chapter, and is further explained by five coloured maps, showing the exposures of successive orographic disturbances; of these—"the post-Carboniferous, post-Jurassic, post-Cretaceous—taken together—were the main building-times of the modern American continent, and each of these orographical disturbances were most violent at the western edge of the region involved" (p. 759).

The limited space at our disposal prevents us from entering into more details of the contents of this suggestive work, which the reader must consult for himself in order to fully appreciate its nature as a piece of connected history, bearing in mind, however, "that it is not a geological survey, but a rapid exploration of a very great area, in which literally nothing but a few isolated details was before known. It is an attempt to read the geology of the Middle Cordilleras, and to present the leading outlines of one of the most impressive sections of the earth's surface film."

For our own part we fully recognize, after perusing this work, not only the arduous labours of Clarence King and his colleagues during their ten years' exploration in the field, but, also, the instructive and systematic manner in which some of the most striking geological and physical features of the region are recorded, as further illustrated in the twenty-eight beautiful plates and the twelve analytical geological maps, interspersed throughout the 800 pages of letterpress.

J. M.

II.—Faune du Calcaire Carbonifère de la Belgique. Par L. G. de Koninck. Folio, pp. 132. Atlas 31 Planches. (F. Hayez: Bruxelles, 1878.)

If ANY apology were needed for the appearance of this valuable addition to palæontological literature, that offered by the distinguished author as the *raison d'être* of this initial volume of a series to be devoted to the fauna of the Carboniferous Limestone of Belgium is surely a most valid one. In 1842 Professor de Koninck, in a somewhat similar work, raised the number of known species from two hundred to nearly five hundred described forms. At the present time, however, more than double that number, or from one thousand to twelve hundred species, from that horizon, are contained in the rich collections of the Royal Museum of Natural History, whence the chief part of the material for this, and the contemplated volumes of "Extraits des Annales du Musée Royale de la Belgique," have been, or will be, derived.

Prefacing his first volume with a brief but clear outline of the limits and nature of the lowest division of the Carboniferous formation, in Belgium, the Carboniferous or "Mountain" Limestone,—M. de Koninck proceeds to a further subdivision into three main groups, each of which is characterized by a distinct biological fauna. Here, as usual in Palæozoic deposits, the Brachiopoda are to the fore as classificatory *indices*. The position of the Visé Limestone, overlying the Devonian, is definitely settled. It comprises the uppermost or most modern beds. This reverses Murchison's grouping, originally followed by the author and other Belgian geologists, but now shown to have been erroneous. The Upper or Visé Limestone is characterized by *Productus giganteus*, the middle series by *Spirifer striatus*, and the Lower or Tournai Limestone by *Spirifer mosquensis*. The entire series, about 800 mètres in thickness, is again subdivided into six beds according to the arrangement of M. E. Dupont.

As no reptilian or amphibian remains have as yet been furnished by the Belgian Carboniferous rocks, this volume is occupied by figures and descriptions of the forty-three species of fishes occurring in the Upper and Lower divisions. The middle beds are entirely barren of piscine remains, and the conditions were evidently unfavourable to their preservation during the deposition of the whole series. For the number represented is less than half that of the described British species from the same epoch. Some of the Belgian forms are, however, very remarkable. Forty belong to the Selachii and the remaining three to the Ganoidei. The interesting Dipnoid discovered by the author and M. van Beneden, *Palædaphas insignis*, does not find a place in this volume, as the horizon originally given as Carboniferous is now known to be of Devonian age. The classification adopted throughout is Dr. Traquair's Müllerian modification of Professor Huxley's system. But M. de Koninck gives only necessary classificatory details, leaving the systematization of the Carboniferous fishes to those possessed of more ample material. Of the fifty-two species of Nautili figured and described, twenty-two are new to science. Several forms are restricted to certain horizons; none make their appearance prior to that epoch, and not one survives it. The genus is abundantly represented in Belgium, but occurs but rarely in Australian deposits of similar age.

The specific descriptions, clear though not diffusive, are accompanied by careful comparisons with European, American, and Australian forms, and liberal recognition is awarded to the labours of predecessors and contemporaries in the same field of inquiry. The atlas comprises thirty-one folio plates of fishes and cephalopods, beautifully executed by G. Severeyns. The work gives promise of a mine of information for comparative purposes to all interested in the history of the fossils of this rich formation, and cannot but add to the acknowledged repute of the author as a distinguished palæontologist. In a word, the "Faune Calcaire Carbonifère de la Belgique," with the Silurian System of M. Barrande, and the "Jura Normand" of M. Eugene Deslongchamps, may be taken as excellent illustrations of the method adopted by foreign authors as historians, not of one especial group of organisms, but of the physical characters and complete fauna of an entire geological formation. By this means local variations in general physical conditions are duly recognized, and uniformity of geological grouping and zoological classification is secured. No English works of a similar nature can rival those above cited in excellence of palæontological illustration, save the decades of the Survey, or the volumes of our Palæontographical Society. A. C.

III.—Brachiopodes Etudes Locales. Par Joachim Barrande. 8vo. pp. 335, and 7 Planches. (Prague, 1879.)

We have here another of those excellent memoirs in which M. Barrande reviews his former labours in the same field; an epitome, in fact, of those lengthened researches, the results of which are embodied in his classical volumes on the Silurian system of Bohemia. To the student these most instructive *résumés* are invaluable as an author's summary of his own investigations, affording information on important points, with references to the exact *locale* of further details. They furnish the author at the same time with an opportunity for revision and addition, rendered necessary by increased discoveries, and for drawing those inferences and conclusions which he is necessarily best qualified to supply.

Although only two species of Brachiopods were known in Bohemia prior to 1840, M. Barrande now transmits about six hundred and forty named Silurian species to his successors. A number which illustrates the exceptional richness of the Bohemian deposits, and the thorough investigations to which they have been subjected through the energy and laborious industry of the author. It considerably exceeds Mr. Davidson's provisional estimate of 210 species from the British Silurian rocks, and almost amounts to half that given by Dr. Bigsby (1422) in his "Thesaurus Siluricus" as the approximate total of known species from the Silurian deposits of the world. Only two of the Bohemian forms are primordial, 124 occur in the second zone, and 521 in the third. Thirty-nine are common to France, and forty-two to the "Septentrional" zone of Europe and America. Three new genera, *Clorinda, Mimulus,* and *Paterula,* all Secondary, or local types, are added.

In this memoir M. Barrande gives some very interesting and novel facts concerning the variations observed in Bohemian forms, treats of their vertical distribution, and specific relations with those of other Palæozoic areas. Thus, it would appear from these researches that neither longevity of type nor the fecundity of a species can be considered as the primary cause of variability. For the long-lived forms often exhibit but few variations, while a species but sparsely represented may be accompanied by numerous examples. Furthermore, that the numerical abundance of a species, on the same horizon, and with a limited area, has apparently no influence upon, or connexion with, the origin of varieties. Some appear simultaneously with the type, others during its existence, while the mutatory forms do not come into being until after its disappearance or extinction. The average vertical distribution is extremely limited. These facts, M. Barrande concludes, are opposed to the conception of the adaptability of the Brachiopods to the environment, and afford no support to the theories of descent by modification. At the same time, it is *en evidence* (Table, p. 162) that generic forms enjoying the longest vertical range, such as *Atrypa, Discina, Orthis*, and *Rhynchonella,* are invariably represented by the greatest number of species.

These local studies in Brachiopoda may not perhaps be of such general interest as the preceding volume on the Cephalopods, but to the student and specialist they afford valuable and novel data with reference to a group of organisms daily becoming more useful as *indices* of palæontological time. Nor can those who are not prepared to accept M. Barrande's views with regard to the separate origin of every individual species, or variety, fail to admire the marvellous energy and vast labours of one of the most distinguished and indefatigable of pioneers in palæontological science. A. C.

IV.—On the Manufacture of Gun-flints, the Methods of Excavating for Flint, the Age of Palæolithic Man, and the Connexion between Neolithic Art and the Gun-flint Trade. By Sydney B. J. Skertchly. [Memoirs of the Geological Survey. 8vo. pp. 80. (London, 1879.) Price 17*s*. 6*d*.]

THE title of this Geological Survey Memoir gives its contents at a glance, and introduces to our notice subjects that possess a far wider interest than do most of the Survey publications. The neighbourhood of Brandon, so well known, through the labours of Messrs. Prestwich, Evans, and Flower, for its palæolithic and neolithic implements, has recently been invested with much additional importance from the researches made by Mr. Skertchly into the geological position of the earlier works of art, and which he has determined to belong to deposits of Interglacial age.

In his present work, the author first places before his readers a very careful and detailed account of the modern manufacture of gun-flints, a trade now steadily dying out, though this decline is not owing, as he tells us, to a falling off in the demand, but to a lack of hands, the boys preferring agricultural and other labours to the confinement of a knapper's shop.

Under such circumstances, the record of the trade, while illustrating the economic applications of geology, possesses an archæological value which time will no doubt enhance.

The particular layers of flint with their local names are described and illustrated in a section of the Chalk at Lingheath, where the flint now manufactured at Brandon is obtained. Other localities, formerly worked, are likewise described, including the gun-flint manufacture once carried on at Beer Head in Devonshire. The various tools employed are explained and figured, and the methods of digging the flint, and of drying, quartering, flaking, and knapping it are similarly illustrated. And in this part of the subject the author acknowledges his indebtedness to Mr. W. J. Southwell, a practical knapper, in whose workshop he learnt the trade, and wrote many of his notes. Each form of gun-flint, from that of the musket to the pocket pistol, is engraved, and full descriptions are given of a set of specimens deposited in the Museum at Jermyn Street.

The author observes that from Palæolithic times to the present day the vicinity of Brandon has been one of the great emporia for flint, and he briefly sums up his conclusions that the early palæolithic implements found in the "Brandon Beds" are older than the Chalky Boulder Clay. The present flint-knappers at Brandon he regards as the direct descendants of the old workers in stone who dug the ancient flint-pits at Grime's Graves, which have been so well described by Canon Greenwell.

V.—Journal of the Royal Microscopical Society. Edited by Frank Crisp, LL.B., B.A., F.L.S., etc. Vol. II. No. 2, April; No. 3, Extra Number, May, 1879. 8vo. (Williams & Norgate, London.)

THERE are so many points in the natural history of plants and animals, and in the nature of rocks, that the microscope assists the geologist in determining, and so many microscopists work ardently at the elucidation of these matters, that we cannot take up any part or volume of the Proceedings of the several Microscopical Societies now flourishing at home or abroad without meeting with some, and often with important, additions to our knowledge. This is the case with the Journal before us. The industrious accumulation of notes and memoranda from British and foreign works adds much to the value of this work; and, with the Bibliography, these are now arranged on a classified plan, referring (1) to the histology and embryology of the Vertebrata; (2) structure and natural history of the Invertebrata, according to classes and orders; (3) general histology and embryology of the Phanerogamia; (4) the Cryptogamia in order; (5) Microscopy and Miscellanea.

REPORTS AND PROCEEDINGS.

British Association for the Advancement of Science, Forty-ninth Meeting, Sheffield, August 20th, 1879.

I.—Titles of Papers Read in Section C. (Geology).

President—Professor P. Martin Duncan, M.B. (Lond.), F.R.S., V.P.G.S.

The President's Address.

Rev. H. W. Crosskey, F.G.S.—Seventh Report of the Committee appointed for the purpose of recording the position, height above the sea, lithological characters, size, and origin of the Erratic Blocks of England, Wales, and Ireland; reporting other matters of interest connected with the same, and taking measures for their preservation.

J. E. Lee, F.G.S.—Notice of the occurrence of a Fish allied to *Coccosteus* in a bed of Devonian Limestone, near Chudleigh.

J. E. Lee, F.G.S.—Notice of Fossils found in a bed of Devonian rocks at Saltern Cove, in Torbay, and in a quarry of the Old Red Sandstone, near Caerleon, in Monmouthshire.

P. H. Carpenter, M.A.—On the Nomenclature of the Crinoidal Calyx.

V. Ball, M.A., F.G.S.—On the Coal Fields and Coal production of India.

J. F. Blake, M.A., F.G.S.—On Geological Episodes.

F. M. Burton, F.G.S.—On the Keuper Beds between Retford and Gainsborough.

F. M. Burton, F.G.S.—On the Northerly extension of the Rhætic Beds at Gainsborough.

W. Pengelly, F.R.S.—Fifteenth Report on the Exploration of Kent's Cavern, Devonshire.

J. Evans, LL.D., F.R.S.—Report on the Bone Caves of Borneo.

Professor W. Boyd Dawkins, M.A., F.R.S.—On the Bone Caves of Derbyshire.

R. J. Ussher and Professor A. L. Adams, M.A., F.R.S.—Discovery of a Bone Cave near Cappagh, County Waterford.

C. Ricketts, M.D., F.G.S.—On some remarkable Pebbles in the Boulder-clay of Cheshire and Lancashire.

The Abbé A. Renard and T. Murray.—On the Volcanic Products of the Deep Sea of the Central Pacific, with reference to the "Challenger" Expedition.

C. Moore, F.G.S.—On Ammonites and Aptychi.

E. W. Claypole.—Notes on a Fossil Tree from the Upper Silurian of Ohio.

J. W. Davis, F.G.S.—On *Ostracocanthus dilatatus* (gen. et sp. nov.), a Fossil Fish from the Coal-measures, S.E. of Halifax, Yorkshire.

E. Wilson, F.G.S.—On the Age of the Pennine Chain.

M. Blair.—On the Foundations of the Town Hall, Paisley, with Notes on the Rocks of Renfrewshire.

Dr. J. Phené, F.S.A.—On the Deposit of Carbonate of Lime at Hierapolis, in Anatolia, and on the Efflorescences of the Limestone at Les Baux, in Provence.

Prof. A. S. Herschel, M.A., F.R.A.S., and *Prof. G. A. Lebour, M.A., F.G.S.*—Sixth Report on the Conductivities of certain Rocks. (Read also before Section A.)

Prof. J. D. Everett, F.R.S.—On some broad features of Underground Temperature.

Prof. W. C. Williamson, F.R.S.—On the Botanical Affinities of Sigillaria and Stigmaria.

S. B. J. Skertchly, F.G.S.—Evidence of the Existence of Palæolithic Man during the Glacial Period in East Anglia. (Read also before Section D.)

J. H. Collins, F.G.S.—On the Geological Age of the Rocks of West Cornwall.

J. Perry.—On the Surface Rocks of Syria.

Rev. G. Blencowe.—On certain Geological Facts observed in Natal and the Border Countries during nineteen years' residence.

C. E. De Rance, F.G.S.—Fifth Report on the Underground Waters in the Permian, New Red Sandstone and Jurassic Formations.

W. Whitaker, B.A., F.G.S.—Report on the Progress of the "Geological Record."

W. J. Sollas, M.A., F.G.S.—On the Replacement of Siliceous Skeletons by Carbonate of Lime.

G. R. Vine.—On Carboniferous Polyzoa and Palæocorynæ.

H. Hicks, M.D., F.G.S.—On the Classification of the British Pre-Cambrian Rocks. (See p. 433.)

R. A. C. Godwin-Austen, F.R.S.—On some further evidence relating to the range of the Palæozoic Rocks beneath the South-east of England.

Prof. G. A. Lebour, M.A., F.G.S.—On "Culm" and "Kulm."

II.—Titles of Papers, Bearing upon Geology, Read in other Sections.

Section B.—Chemical Science.

W. Ivison Macadam.—On the Chemical Composition of a nodule of Ozokerite found at Kinghorn-ness.

Thos. Andrews.—On some curious Concretion Balls derived from a Colliery Mineral Water.

W. Thomson, F.R.S.E.—Notes on a sample of Fuller's Earth found in an old Fullonica recently excavated at Pompeii.

Section D.—Biology.

Report of the Committee on preparing plates illustrating a Monograph on the Mammoth.

S. B. J. Skertchly, F.G.S.—On a new Estimate of the Neolithic Age.

E. B. Tylor, D.C.L., F.R.S.—Address to the Department of Anthropology.

James Knowles.—On Flint Implements from the Valley of the Bann.

V. Ball, M.A., F.G.S.—On the Forms and Geographical Distribution of Ancient Stone Implements in India.

J. W. Davis, F.S.A., F.G.S.—On the Discovery of Chipped Flints beneath Peat on the Yorkshire Moors.

Professor W. Boyd Dawkins, M.A., F.R.S.—On the Geological Evidence as to the Antiquity of Man.

S. B. J. Skertchly, F.G.S.—On the Survival of the Neolithic Period at Brandon, Suffolk.

John Milne, F.G.S.—On the Stone Age in Japan.

Section E.—Geography.

C. R. Markham, C.B., F.R.S.—Opening Address.—The Valley of the Don.

B. Tower.—The Physical Aspects of Zululand and Natal.

Trelawny Saunders.—On the Orography of the north-west frontier of India.

Section G.—Mechanical Science.

Baldwin Latham.—On the Temperature of Town Water Supplies.

Joseph Lucas.—On the Quantitative Elements in Hydrogeology.

CORRESPONDENCE.

A NEW LAKE IN THE PISTOJESE MOUNTAINS.

Sir,—An interesting example of lake-formation has recently been noticed in one of the valleys of the Apennines by my friend Captain Cecil Norton, 5th Lancers. The road from Florence by Pistoja to Modena crosses the mountain-range at Boscolungo, where the limestone rocks form a semicircular arc, facing the south; and from the northern side of this ridge a spur juts out towards the north-east, and forms a V-shaped valley, giving rise to a small tributary of the river on which Modena is situated. On the neighbouring heights the snow occasionally lies until late in the year. During the last summer, as late as August 25th, snow was lying near Abetone, the mountain-top of Boscolungo, and about 4,500 feet high; also away eastward, on the hill-tops on the southern side of the gorge beyond Monte Cimone, which is the crest, 6,700 feet high, at the head of the valley above mentioned. As in the Alps and elsewhere, these Italian snows are subject to sudden meltings, though it is said to be fifty years since so rapid a thaw, or such a flood of snow-water, has been recorded as that of this year. The mountains here, it will be remembered, are composed of limestone and sandy macigno, and therefore so highly susceptible of frost-action that the accumulation of débris on and at the foot of the slopes is often considerable. Some time in June last so sudden and rapid a melting of the snow occurred as to sweep down a large mass of débris, sufficient indeed to completely block the bed of the rivulet above mentioned, forming one of the head-waters of the Modena river. The result was the formation of a lake, some 300 or 400 yards long, by 150 or 200 yards wide, at the time when it was seen (from the pass) on the 24th August.

It will be interesting to notice hereafter what effect the retention of the water will have on the dam of this little lake. Will the dam be violently cut through, or totally swept away, by gradually accumulated water? Will it be strong enough to withstand the pressure? Will it be quietly worn down by the overflow, so as to allow of the gradual lowering of the lake? Will it be undermined by the destruction of its lower part? In any case the débris left will be moraine-like in character; and might, but for the want of the regular *striæ*, be mistaken for the results of an old glacier.

Thus, it may be instructive to place on record this formation of a moraine-like heap, which, without careful examination as well of detail as of general appearance and situation, might at some future time be attributed to the action of a force very different from that which brought it to its place. T. Rupert Jones.

Staff College, Camberley,
Sept. 16th, 1879.

INTERGLACIAL PERIODS.

SIR,—In the last Number of this MAGAZINE Mr. McGee does me the honour to refer to the theory which I have advanced to account for those warm interglacial periods, of which the records are preserved in most highly glaciated regions which have been examined with adequate attention. As Mr. McGee appears to have misunderstood what I have written, and to have fallen into a misapprehension in regard to the melting of polar ice, perhaps you will kindly allow me, for the sake of those not familiar with the subject, to point out where he has gone wrong. I have not, as he supposes, assumed that the comparative disappearance of ice on the warm hemisphere, during the period of high excentricity, is due to any additional heat derived from the sun in consequence of the greater length of the summer, for there is no such increment. A *shortening* of the winter, or snow-falling season, would no doubt considerably diminish the quantity of the ice; but the mere *lengthening* of the summer would have little effect. The real and effective cause of the disappearance of the ice was the enormous transference of equatorial heat to temperate and polar regions by means of ocean currents. My theory holds that the polar ice was melted mainly by heat carried from equatorial regions, rather than by the direct rays of the sun.

Mr. McGee calculates that only ·615 of a foot of polar ice would be melted annually; but there is no reason why there may not have been more than twenty times that quantity. JAMES CROLL.

PALÆOLITHIC IMPLEMENT FOUND IN DEVONSHIRE.

SIR,—About a month ago I had the good fortune to find a palæolithic implement in the parish of Kentisbeare. It is, I believe, the first which has been found in the valley of the Culm. Some time ago Mr. H. B. Woodward suggested to me the probability that palæolithic implements might be found here. When, therefore, his forecast was verified, I wrote to him informing him of the fact, and I am now writing to you at his suggestion. I found it on a heap of stones collected from a field and piled up in the corner of the field for removal as road metal. It is of bluish chert, weathered white. The field is one only lately brought into cultivation, has a thin peaty soil, and is situated near the centre of Ordnance Sheet XXI., where the words "Kentisbere Moor" occur; and its exact position would be about the middle of the word "Moor." It must have lain at no great distance beneath the surface, and have either been brought up by the plough, or by ditching and draining work. I have shown it to Mr. D'Urban, Curator of the Albert Memorial Museum at Exeter, and to Mr. P. O. Hutchinson, of Sidmouth, the latter of whom has kindly taken the inclosed rubbing. As, however, the rubbing does not quite correctly represent the shape (for the surface when spread out will of course slightly exceed the actual breadth) I have traced its outline, and shown the extreme length and breadth.[1] W. DOWNES.

KENTISBEARE, COLLUMPTON, DEVON, *Sept.* 12, 1879.

[1] The implement agrees closely with that drawn in Dr. John Evans's invaluable work on Ancient Stone Implements, plate ii. fig. 17.—EDIT. GEOL. MAG.

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ORIGINAL ARTICLES.

I.—On the Rocks of Brazil Wood, Charnwood Forest.

By S. Allport, F.G.S.

An interesting discovery having just been made in consequence of the examination of a single thin slice of rock, the following communication is recommended to the attention of those geologists who, to say the least, still fail to recognize the value of the microscope in geological investigations.

A short time since, a friend in Leicester kindly sent me a specimen of the so-called gneiss from Brazil Wood; having prepared a thin section and placed it under the microscope, I immediately recognized an old acquaintance. It so closely resembled some of the altered clay-slates which surround the Land's End mass of granite,[1] that I could not but regard it as another illustration of contact metamorphism, and the following day was devoted to an examination of the locality in which it occurs.

Under the guidance of Mr. W. J. Harrison, of Leicester, who kindly accompanied me, a small quarry in the wood was soon found, and in a few minutes we were gratified by the discovery of a mass of granite in contact with the "gneiss." It is at present the only known junction of the granite with the old sedimentary rocks, and proves conclusively that, like the syenites of the district, the granite is also an intrusive rock. Subsequently to our visit, Mr. Harrison has discovered a bed of indurated banded slate overlying the gneiss; it has a distinct cleavage, and contains numerous small garnets. This slaty rock is interbedded with another which is rather more compact, and has a less perfect cleavage; it also contains garnets. The discovery of these slaty rocks is another point of interest, as none have been previously observed to the east of the Swithland slates. There can be no doubt that they belong to the Charnwood series, and it will be seen that their altered condition may be fully explained by their close proximity to the intrusive granite. As the locality in which these discoveries have been made has been frequently visited and described, it may afford satisfaction to previous observers to learn that the granite just found has been exposed to view by very recent quarrying of the rock.

The microscopic structure of the Mount Sorrel granite, and of

[1] Described by me in Quart. Journ. Geol. Soc. 1876, vol. xxxii. p. 407.

many other Charnwood rocks, has quite recently been admirably described by Messrs. Hill and Bonney in a most valuable paper read before the Geological Society;[1] it will therefore suffice to give a short account of two masses of granite and the altered sedimentary rock.

In Brazil Wood a small conical hill of granite rises about 70 or 80 feet above the surface, and is separated from the knoll of "gneiss" by an interval of 35 yards; this depression is occupied by soil and vegetation, so that the junction of the two rocks cannot be observed. On the occasion of our visit we found that recent excavations had been made in the north-west corner of the quarry, and had exposed to view a mass of granite which clearly forms part of an intrusive vein. In one place there is a piece of the gneiss completely inclosed in it, and it has thrown off smaller veins which penetrate the gneiss in various directions. It will be seen, then, that the beds of "gneiss" and slate are within 35 yards (measured along the surface) of a considerable mass of granite, and that they are also penetrated by granite veins; they have been subjected, therefore, to influences of the same kind which, in Cornwall and elsewhere, have converted ordinary clay-slates into crystalline micaceous schists.

Hornblendic Granite, Brazil Wood.—The rock forming the conical hill is a rather fine-grained granite of dark colour; its constituents are orthoclase, plagioclase, quartz, hornblende, biotite, magnetite, and a few long slender prisms of a light brown colour not determined. Although orthoclase predominates, the triclinic felspar is very abundant, and occurs here and there in rather large crystals beautifully striated. Both felspars are in a remarkably fresh state of preservation. Hornblende of a brownish-green colour is abundant, and is frequently quite unaltered; other crystals are however either partially or completely altered to a green fibrous variety which closely resembles uralitic pseudomorphs after augite. The *Biotite* is occasionally quite unchanged, and exhibits its usual optical characters; much of it has, however, been altered to a pale green substance, which is less strongly dichroic. The rock is a good one for the study of this mineral, as it may be seen in every stage of alteration.

Quartz is plentiful and contains many minute fluid cavities.

Granite intrusive in schist.—This rock is also rather fine-grained, but contains many crystals of white felspar, which give it a somewhat porphyritic character. The constituents are orthoclase, plagioclase, quartz, biotite. Both felspars are well preserved; the orthoclase exhibits many Carlsbad twins; the plagioclase is comparatively clear, and shows a very characteristic twin striation. The mica agrees in every way with that described in the last-named rock.

The *Quartz* is clear, but contains numerous very minute cavities disposed in parallel lines; it is worthy of remark that the direction of these lines is the same in several adjacent grains of quartz. There are a few small garnets near the junction with the schist, but none have been observed at a greater distance than an inch. It is

[1] Quart. Journ. Geol. Soc. 1877–78, vols. xxxiii. and xxxiv.

remarkable that hornblende should be absent, as it occurs in all the other granites of the district.

The junction with the schist is interesting, as it presents two varieties. In one specimen the junction is as sharp and distinct a line, as in any of the Cornish examples described in the paper already quoted; in others, it is not so well defined; the two rocks have, in fact, been so completely blended together, that there is a narrow band of such indefinite character, that one can hardly say to a quarter of an inch where one begins and the other ends. A thin slice shows under the microscope a narrow belt between normal granite and normal schist, which consists almost exclusively of imperfectly developed felspar crystals and mica. This felspathic band is also marked by the presence of numerous minute black grains of magnetite, which are here and there loosely aggregated in clusters. The slice contains small garnets in both the granite and schist.

Micaceous Schist.—The rock into which the granite has been intruded has been called a peculiar or unique gneiss; it is, in fact, so peculiar that the term is inappropriate, as the rock has neither the mineral composition nor the structure of gneiss; it contains no recognizable felspar, and there is no true foliation. It is tough and difficult to break, though rather more fissile in one direction than in others; it is purplish grey in colour, and glitters with numerous bright flakes of mica. The description of its microscopic structure given by Professor Bonney in the paper already cited agrees in the main with my own observations; in my slices there is, however, so little of the "fine granular base," that I should prefer to describe it as a rock consisting almost entirely of two micas, with a few grains of quartz, and numerous minute black grains (doubtless magnetite) irregularly scattered through the mass; and, in addition, there are occasional small patches of the fine granular substance showing aggregate polarization; it occupies spaces between the flakes of mica, but exhibits no crystalline forms. There are also small flakes and streaks of clear red ferric oxide. The brown and greenish-brown mica has all the characters of altered biotite. The white mica is more abundant, and occurs here and there in rather large flakes; in its brilliant chromatic polarization, and other optical characters, it agrees perfectly with a white mica in the altered clay-slate in contact with the granite of St. Michael's Mount, Cornwall. As it is not quite like muscovite, it may probably be paragonite as suggested to me by Prof. Bonney; and this would agree well with the analysis given by him at p. 224, as that mineral contains from 36 to 40 per cent. of alumina. As regards structure, there is no approach to foliation in any of my slices; the constituents lie in all possible directions without any definite arrangement. There is, however, a banded appearance in some specimens caused by the crystallization of the two micas in rather larger plates along roughly parallel lines. Near the junction with the granite the schist contains many small garnets, which are interesting microscopic objects.

It will be seen, then, that this schist is neither a gneiss nor a true mica-schist; it belongs, in fact, to a group of rocks which have not yet received distinctive names, although they are far from uncommon. They occur round the skirts of granitic masses, especially when the latter have broken through clay-slates. When the prevailing constituent is mica, and they are more or less fissile in one direction, they may for the present be called micaceous schists, in order to distinguish them from normal mica-schists. This Charnwood rock is singularly like some of the Devonian slates near their junction with the Land's End granite, it is not more highly altered, and the present crystalline condition of both may clearly be explained by the same cause, namely, their contact with large masses of intrusive granite.

It may possibly be objected to this explanation that no such amount of alteration has been produced in the sedimentary rocks of the district by the intrusion of the syenite. It must not be understood, however, that the syenite has produced no effect whatever. But the two cases are not strictly analogous, and the following considerations may probably suffice to remove the apparent difficulty. If we regard the large masses of granite which occur among our Palæozoic strata as crystalline products formed at the roots of old volcanos, and subsequently exposed by denudation, it is evident that the surrounding rocks must have been exposed to great heat and intense metamorphic action during the entire period of volcanic activity; whereas rocks lying at a distance would receive no more heat than that given out by any gradually cooling masses which might be intruded among them. In the first case, the heat would be far more intense and continuous; in fact, its duration might probably be measured by an entire geological period; while in the second, the heat would be far less at the commencement, would be a gradually diminishing quantity, and the duration of its efficient action might be reckoned by years. Sheets of molten matter intruded among rocks at a distance of a very few miles would everywhere meet with cold surfaces, and would necessarily be cooled down at a comparatively rapid rate. It has frequently been observed that granite has produced greater alteration in contiguous strata than other intrusive rocks; but it is also true that the amount of change is very unequal, sometimes being comparatively slight. Such facts are quite in accordance with the theory here advocated. Leaving out of consideration any inequality due to differences of composition in the rocks attacked, it is probable that prolonged volcanic action would vary greatly in intensity at different times and in various directions. It might then easily occur that the molten material of granite forcing its way through strata towards the close of a volcanic period would produce far less effect than in the earlier stages of activity; or the occasional transfer of the volcanic source from point to point during periods of varying length would also account for very considerable variations in the amount of alteration produced.

The slaty rock overlying the micaceous schist is very fine grained, and may fairly be described as an indurated banded slate. Although highly altered, the mass is less perfectly crystallized than in the schist, and has more the character of a spotted slate; minute red granules and flakes of brown mica being grouped in clusters and straggling lines. A very thin slice examined with a quarter-inch objective shows that the mass is in a crystalline state, and crowded with minute flakes of white mica. This difference in the condition of the two adjacent beds is common in the Cornish rocks, and is doubtless due to original differences of composition or texture in the sedimentary deposits.

II.—Notes on the Fossil Flora of Eastern Australia and Tasmania.

By Dr. Ottokar Feistmantel,
of the Geological Survey of India, Calcutta.

Through the kindness of the late Rev. W. B. Clarke, of Sydney, I had the opportunity of examining two collections of fossil plants from Australia, which that gentleman had kindly placed at my disposal, together with explanatory notes, which he communicated to me in private letters.

My own remarks upon the plants contained in the first collection (which I obtained three years ago) were published in the 4th edition of Mr. Clarke's "Remarks on the Sedimentary Rocks of New South Wales," 1878, but they require a few corrections now. The descriptions of the plants and figures were published by me in the "Palæontographica," 1878–79.

The second collection sent by Mr. Clarke contained also numerous new forms; besides this, Mr. C. S. Wilkinson, another Australian geologist, has recently contributed some specimens from the Hawkesbury beds (see further on), and as in the mean time Mr. Clarke's above-mentioned work was published, and also Mr. R. Etheridge's "Catalogue of Australian Fossils," I was enabled to write a supplemental memoir (with several plates), on the fossil Flora in Australia.

Before it can, however, be published, I may be permitted to give a short account of the present state of our knowledge of this Flora; but the Palæozoic and Mesozoic forms only are here taken into consideration.

I shall first indicate the stratigraphical classification of the beds containing the plants, based upon the observations of the most trustworthy authors, and shall then proceed to a short systematic discussion of the Flora (with addition of the few fish remains).

I. Queensland.

The best account of the Geology is found in Daintree: Geology of Queensland, Quart. Journ. Geol. Soc. 1872, vol. xxviii. The plants are described by Mr. W. Carruthers, F.R.S.

The following classification is given:

1. *Carbonaceous* (Mesozoic strata) (see *l.c.* pp. 273, 283). *Tæniopteris Coal-measures* (*l.c.* p. 288 and p. 325). Localities: Brisbane, Tivoli Mines, near Ipswich, etc.

Fossil plants, described by Mr. Carruthers (from Tivoli Mines): *Pecopteris* (*Thinnfeldia*) *odontopteroides*, Morr. (Fstm.); *Tæniopteris Daintreei*, Carr.,[1] *Cyclopteris cuneata*, Carr., *Sphenopteris elongata*, Carr., *Cardiocarpum australe*, Carr.

In Mr. Clarke's second collection there were several specimens from near Talgai, and I determined the following: *Tæniopteris Daintreei*, M'Coy (the original form), *Sagenopteris rhoifolia*, Presl, and an *Otozamites*[2] (comp. *Mandelslohi*, Kurr.). These beds are equivalent with the Upper Mesozoic beds in New South Wales, Victoria and Tasmania (see Daintree, *l.c.* p. 288).

2. *Carboniferous* (Palæozoic). — The northern Coal-fields in Queensland (Daintree, *l.c.* pp. 273, 285, etc.).

Plants, generically only mentioned: *Glossopteris*, *Schizopteris*, *Pecopteris*, etc.

Apparently on the horizon of the "Lower Coal-measures" in New South Wales.

3. *Devonian* (Daintree, *l.c.* pp. 273, 288–9), etc.

Localities: Mount Wyatt, Canoona and Broken River, etc.

Fossil Plants: *Lepidodendron nothum*, Ung. (Carr), *Cyclostigma*, sp.

Equivalent: The Devonian beds (Goonoo-Goonoo), with the same plants in New South Wales.

II. New South Wales.

For stratigraphical descriptions, see Strzelecki,[3] Dana,[4] Clarke,[5] and Wilkinson.[6] Plants were described by Morris (in Strzelecki, *l.c.*), Dana (*l.c.*), M'Coy (*l.c.*), and lately by myself.[7] Some fishes were described by Dana (*l.c.*), and Sir P. Egerton.[8]

1. *Mesozoic* (see Wilkinson, *l.c.* p. 127). Certain beds on the Clarence River—with *Tæniopteris Daintreei*, M'Coy (the real form), and *Alethopteris australis*, Morr.

These beds are to be classed with Mr. Daintree's *Tæniopteris*-beds in Queensland. Other equivalents: Upper Mesozoic beds in Victoria and Tasmania.

2. *Wianamatta and Hawkesbury beds* (see Clarke, *l.c.* pp. 70 and 72), classed under the heading "Mesozoic, or Secondary formations" (Clarke, *l.c.* p. 68 *et seq.*), and in another place as "Supra-Carboniferous" (Clarke, *l.c.* p. 155).

Localities: Clark's Hill, Paramatta, etc., Wianamatta beds;—Cockatoo Island, Mt. Victoria, etc., Hawkesbury beds.

Fossils: Fishes and Plants.

Fishes partly heterocercal. Of plants I mention now *Pecopteris odontopteroides*, Morr.,[9] only; *this species is not known lower than the*

[1] This seems to differ from M'Coy's original form from Victoria.
[2] These two are new for Australia.
[3] Physic. Descr. of N. S. Wales and Van Diemans Land, 1845.
[4] United States Exploring Expedition, Geology, 1849.
[5] Ann. and Mag. Nat. Hist. vol. xx. ser. 2, 1847.
[6] In Mines and Miner. Statistics of N. S. Wales, 1875.
[7] Palæontographica, 1878–79.
[8] On some Ichthyolites from New S. Wales Q. J. G. S. vol. xx. 1864, p. 1.
[9] I class it with *Thinnfeldia*.

Hawkesbury beds." (I explain further on that the quotation of it in the "Newcastle beds" is a mistake.)

3. *Upper Palæozoic* (Clarke, *l.c.* p. 27). Mr. Clarke distinguishes several subdivisions (see *l.c.* p. 66).

a. Upper Coal-measures, or otherwise called Newcastle beds.

Localities: Black-man's-swamp, Bowenfels, Guntawang, Mudgee, Illawara, Mulubimba, Newcastle, Wollongong, etc.

Fossils: *Urosthenes australis*, Dan. (heterocercal).

Plants very frequent—mostly: *Phyllotheca australis*, Brong., *Vertebraria* (*australis*, M'Coy), several species of *Sphenopteris*, several species of *Glossopteris* (very numerous), one *Gangamopteris*, *Cycadeaceous* leaves (*Nöggerathiopsis* and *Zeugophyllites*), etc.

These Coal-beds were considered by Prof. M'Coy as "Oolitic," and Mr. R. Etheridge (*l.c.*) also classes them as "Mesozoic," while Mr. W. B. Clarke includes them under his heading "Palæozoic." I myself classed them under the heading "Strata above the marine Fauna," and my belief is, that they are younger than the Lower Coal-measures (below the marine Fauna).

b. Upper Marine Beds.

c. Lower Coal-measures. Localities: Anvil Creek, Greta, Harper's Hill, Rix's Creek, Stony Creek, etc., with *Phyllotheca*, several species of *Glossopteris*,[1] and *Nöggerathiopsis*. Also an *Annularia*.

Localities: Arowa, Port Stephens and Smith's Creek, with "Lower Carboniferous plants," as *Calamites radiatus*, Brong., *Sphenophyllum* sp., *Rhacopteris* comp. *inæquilatera*, Göpp., and several other species; *Archæopteris*, *Cyclostigma australe*, Fstm., *Lepidodendron Volkmannianum*, Sternb., *Lep. Veltheimianum*, Sternb., etc. Also a *Glossopteris*.[2]

d. Lower Marine Beds.

4. *Middle Palæozoic.*—Devonian strata, of Goonoo-Goonoo, on the Peel River and Back Creek diggings, on the Barrington River, with *Lepidodendron nothum*, Ung. (Carr.), and *Cyclostigma*, sp.

Equivalents: The Devonian beds of Queensland, with the same fossil plants.

III. Victoria.

For the stratigraphy and fossil Flora of the plant-bearing beds in Victoria, we have to consult:—

M'Coy, Prodromus of a Palæontology of Victoria, Decades I.–V. (1874–77).

Brough Smyth, Reports of Progress of the Geol. Survey of Victoria, 1876 *et seq.*

1. *Upper Mesozoic* (Bellarine beds).—Localities: Barrabool Hills, Bellarine, Cape Paterson, Coleraine (Wannon River).

Fossils (plants): *Phyllotheca australis*, Brong., *Alethopteris australis*, Morr., *Tæniopteris Daintreei*, M'Coy, and three species of *Zamites* (partly *Podozamites*).

[1] Several species described by myself.

[2] This is on the authority of Prof. M'Coy, who quotes from Arowa a *Glossopteris linearis*, M'Coy, together with an *Otopteris ovata*, M'Coy, which, however, is a *Rhacopteris*, comp. *inæquilatera*, Göpp.

Equivalents: Mesozoic beds in Queensland, in New South Wales (and in Tasmania).

2. *Lower Mesozoic* beds (Bacchus Marsh sandstones), of Bacchus Marsh (W.N.W. of Melbourne); also termed the *Gangamopteris* beds, having yielded, as far as known at present, one genus of fossil plants only, namely, *Gangamopteris*, M'Coy, with four species: *Gang. angustifolia, longifolia, spatulata,* and *obliqua.*

Gangamopteris is a genus allied to *Glossopteris*, having the same netted venation—but *no* midrib. This circumstance, as well as the occurrence of *Gang. angustifolia*, M'Coy, in the Upper Coal-measures (Newcastle beds) in New South Wales, brings these beds in a certain relation to the Bacchus Marsh sandstones, which, however, very likely are a little younger—but at all events not older than the Newcastle beds. This is of great importance, as I believe that the Bacchus Marsh sandstones, with their abundance of *Gangamopteris*, represent, to a certain extent at least, the basal beds (the Talchir beds) of the Indian Gondwana system, in which *Gangamopteris* is also very numerous, in which case it would then be impossible to correlate the Indian Coal-strata (Damuda Series) with the Lower (Palæozoic) Coal-measures in Australia.

3. *Carboniferous* (Avon River sandstones), on the Avon River, in Gippsland, with *Lepidodendron australe*, M'Coy.

4. *Devonian* (Iguana Creek sandstones), on the Iguana Creek, Gippsland, with *Sphenopteris Iguanensis*, M'Coy, *Aneimites Iguanensis*, M'Coy, *Archæopteris Howitti*, M'Coy, *Cordaites australis*, M'Coy.

IV. Tasmania.

1. *Mesozoic.*—Count Strzelecki described certain beds on the Spring Hills, Jerusalem's Basin, containing *Pecopteris* (*Alethopteris*) *australis*, Morr., *Pecopteris odontopteroides*, Morr., and *Zeugophyllites elongatus*, Morr., as doubtfully dipping below other beds, with *Pachydomus globosus*, from which it was, of course, afterwards inferred that these plant-beds were Palæozoic. But Prof. M'Coy [1] clearly stated that Mr. Selwyn, the Director of the Victorian Geol. Survey, who made an official Survey of the Tasmanian Coal-fields, found the *Pachydomus*-beds in their natural position, under the Coal-beds.

Moreover, Mr. Crepin, in his note [2] on *Pecopteris odontopteroides* from the Jerusalem's Basin in Tasmania, states, that on the same specimens of shale together with this species occurred still another fossil plant, *Sphenopteris elongata*, Carr., just as it was observed on specimens from the Mesozoic beds in Queensland, which certainly leaves little doubt as to the homotaxis of these beds in Tasmania, when compared with those in Queensland, and consequently also in New South Wales and in Victoria.

I shall now enumerate and shortly discuss the fossils (including the few fishes), as we know them at present from the Australian plant-bearing (coal-bearing) strata.

[1] In Trans. R. Soc. of Victoria, vol. v. 1860, p. 104.
[2] Bull. de l'Acad. Royale de Belgique, 1875, vol. xxxix. pp. 258-263.

A. Animalia.— *PISCES*:—*Urosthenes Australis*, Dan., a heterocercal fish, from the "Upper Coal-measure" (Newcastle beds) in New South Wales.

Palæoniscus antipodeus, Egert., Wianamatta beds, N. S. W.; heterocercal.

Cleithrolepis granulatus, Eg., Wianamatta and Hawkesbury beds, N. S. W. (not apparently heterocercal).

Myriolepis Clarkei, Eg., Hawkesbury beds, N. S. W. (tail not known).

B. Plantæ.—1.—*EQUISETACEA*:—Genus *Phyllotheca*. This genus appears in Australia in the "Lower Coal-measures" (below the first marine Fauna), is most numerous in the Upper Coal-measures (Newcastle beds), and is still found in the Upper Mesozoic beds.

Otherwise the genus is known in Europe from Jurassic beds only (Italy), in Siberia also from the Jura, and in India from the upper portion of the Coal-beds.

Phyllotheca australis, Brong., Victoria (Upp. Mesoz.) and New South Wales (Upp. Coal-m.). I am not aware whether the form in the Lower Coal-measures belongs to this species also, or to another one.

Genus *Vertebraria*, Royle — a plant of doubtful systematical position—but most probably rhizome and rootlets of an Equisetaceous plant—very likely of *Pyllotheca*. Known from the Upper Coal-measures (Newcastle beds) in N. S. W., and from the Indian Coal-beds. The species is *Vertebraria australis*, M'Coy.

Calamites radiatus, Brong. From the Lower Carboniferous beds, Smith's Creek, near Stroud, N. S. Wales. (Figured by me for the first time.)

Annularia australis, Fstm. From the Lower Coal-measures at Greta, N. S. Wales. The only form of this genus in Australia.

Sphenophyllum sp. Fragmentary specimens from the Lower Carboniferous at Port Stephens, N. S. Wales.

2.—*FILICES*:—Genus *Sphenopteris*—six species from the Upper Coal-measures (Newcastle beds) in N. S. Wales (by Morris and M'Coy); one species from the Devonian in Victoria (Iguana Creek).

Sphenopteris elongata, Carr. (together with *Pecopt. odontopteroides*), from the Mesozoic coal-strata in Queensland (Tivoli Mines), and Tasmania (Jerusalem's Basin).

Aneimites Iguanensis, M'Coy, Devonian, Iguana Creek, Victoria.

Archæopteris Howitti, M'Coy, Devonian, Iguana Creek, Victoria.

Arch. Wilkinsoni, Fstm. *Archæopteris* sp., Lower Carboniferous, Smith's Creek (near Stroud), N. S. Wales.

Genus *Rhacopteris* was rather numerous in the Lower Carboniferous beds.

Rhacopteris, comp. *inæquilatera*, Göpp., Smith's Creek (Stroud), N. S. Wales. Mr. W. B. Clarke sent also two specimens of M'Coy's *Otopteris ovata* from Arowa; but after careful comparison, I arrived at the conclusion that this species is identical with those forms which I refer to the above species, so that the locality Arowa is also to be included amongst the Lower Carboniferous localities.

Rhacopteris intermedia, Fstm., Port Stephens; *Rh.* comp. *Römeri*, Fstm., Smith's Creek (Stroud); *Rh. septentrionalis*, Fstm. ibidem.

Thinnfeldia (*Pecopteris*) *odontopteroides*, Morr. Prof. Morris described in Strzelecki's work certain ferns from the Jerusalem's Basin in Tasmania as *Pecopteris odontopteroides*; it was found in those beds, which I mentioned before, as doubtfully dipping below the *Pachydomus* beds. Prof. M'Coy referred it to *Gleichenites*. Mr. Carruthers described and figured it again as *Pecopteris odontopteroides* from Queensland.[1] Recently, Mr. Crepin (*l.c.*) discussed and figured several specimens of this species, also from Tasmania; they agree very well with those from Queensland. Relying apparently upon Count Strzelecki's description, he considered the Jerusalem's Basin as Carboniferous, and took the plant to be an *Odontopteris*, comparing it with Prof. Geinitz's *Odontopteris alpina*. But, at the same time, he made the important statement, which I mentioned before, about the association of this plant with *Sphenopteris elongata* in Tasmania. In my papers on the Australian Flora, I gave figures of specimens from Queensland, Tasmania, and from the Wianamatta and Hawkesbury beds in N. S. Wales. A careful examination of these specimens from the different localities showed them to belong to one and the same form, and I think that, from reasons which I have given elsewhere, it belongs to *Thinnfeldia*.

It is known from the Upper Mesozoic beds in Queensland and Tasmania, and from the Wianamatta-Hawkesbury beds in New South Wales—but *not* from the "Upper Coal-measures" (Newcastle beds) in N. S. Wales. The quotation of this species from the Newcastle beds in my paper was a mistake, caused by my considering the locality "Clark's Hill," in New South Wales, as belonging to the Upper Coal-measures, while it belongs to the Wianamatta beds.

Odontopteris microphylla, M'Coy, Wianamatta beds (and not Newcastle beds).

Cyclopteris cuneata, Carr., Upper Mesozoic, Queensland.

Alethopteris (*Pecopteris*) *australis*, Morr. At present known from the Upper Mesozoic beds only (Clarence River, New South Wales; Victoria; Tasmania); but not from the Newcastle beds in N. S. Wales.

Pecopteris? tenuifolia, M'Coy, and *Gleichenia dubia*, Fstm., from the Wianamatta beds, N. S. Wales.

Tœniopteris (*Angiopteridium*) *Daintreei*, M'Coy, Upper Mesozoic beds in Queensland (Talgai); New S. Wales (Clarence River), and Victoria.

Macrotœniopteris Wianamattœ, Fstm., Wianamatta beds.

Genus *Glossopteris*, Brong. This genus, as far as is known at present, begins, in Australia, in the Lower Carboniferous beds, and is most frequent in the "Upper Coal-measures" of New South Wales. In India it is found in the Coal-measures (Talchir and Damuda Series), in the Panchet group, and in the Jabalpur group (Jura). In Africa in the Karoo beds.

[1] His specimens differ, however, somewhat from Morris's original type—but later quite similar forms were also found in the Jerusalem's Basin, Tasmania; Morris's specimens were altogether badly preserved.

Prof. Trautschold described one species from the Russian Jura.

Glossopt. Browniana, Brong., *Gl. elegans*, Fstm., *Gl. primæva*, Fstm., *Gl. Clarkei*, Fstm., *Gl. linearis*, M'Coy, from the Lower Coal-measures (Greta, Stony Creek), New South Wales, and the Lower Carboniferous (Arowa), N. S. W.

Glossopt. Browniana, Brong., *Gl. ampla*, Dan., *Gl. reticulum*, Dan., *Gl. elongata*, Dan., *Gl. cordata*, Dan., Gl. *Tæniopteroides*, Fstm., *Gl. Wilkinsoni*, Fstm., *Gl. parallela*, Fstm., from the Newcastle beds (Upper Coal-measures), New South Wales.

Gangamopteris obliqua, *Gang. spatulata*, and *G. angustifolia*, M'Coy, from the Bacchus Marsh sandstones (Lower Mesozoic), Victoria. The importance of these forms, was pointed out before, when the Bacchus Marsh sandstones were mentioned.

Gangamopteris angustifolia, M'Coy, from the Newcastle beds (Upper Coal-measures).

Sagenopteris rhoifolia, Presl, from the Talgai diggings, Queensland.

Sagenopt. Tasmanica, Fstm., from the Mesozoic beds in Tasmania.

3.—*LYCOPODIACEÆ:—Lepidodendron nothum*, Ung. (Carr.), Devonian, Queensland (Mt. Wyatt, Broken River, etc.); New South Wales (Goonoo-Goonoo on the Peel River, Back Creek diggings on the Barrington River).

Lepidodendron Veltheimianum, Sternb., and *Volkmannianum*, Sternb., Lower Carboniferous, Smith's Creek (near Stroud), New South Wales. The Rev. W. B. Clarke's specimen of *Lepid. rimosum*, Sternb., of which he sent a photograph, seems to belong to *Lep. Veltheimianum*, Sternb.

Lepidodendron dichotomum (?), Sternb., Lower Carboniferous, Smith's Creek (Stroud), New South Wales.

Cyclostigma australe, Fstm., from the Lower Carboniferous, Smith's Creek (near Stroud), New South Wales. This plant, together with the others from the same locality, appeared to me to indicate Prof. Heer's "Ursastufe."

4.—*CYCADEACEÆ:—Otozamites* (comp. *Mandelslohi*,[1] Kurr.).—The first *Otozamites* from Australia, Talgai diggings, Queensland (Upper Mesozoic Coal-beds).

Genus *Nöggerathiopsis*, Fstm.—I established this generic name (1878) for those leaves which, in India and Australia, were described as *Nöggerathia.* When examining, last year, the Indian leaves, I found that they differed from *Nöggerathia*, and named them *Nöggerathiopsis;* finding afterwards that the Australian leaves also belong to this genus, the same name is now used for them.

Similar leaves were described from the Altai by Prof. Göppert, also with the generic name *Nöggerathia*, and the formation was described as Permian. Prof. Schmalhausen (Kiev) has, however, recently stated that this Flora from the Altai, and another Flora on the Upper Tunguska (which at first was also considered Carboniferous), are, in fact, of a Jurassic age; the said *Nöggerathia* was placed by him in a new genus, *Rhiptozamites;* it appears that *Nöggerathiopsis* and *Rhiptozamites* are closely allied genera, probably identical.

[1] This is probably a misprint for *Mendelsohni.*—Edit. Geol. Mag.

Nöggerathiopsis prisca, Fstm., Lower Coal-measures, Greta, New South Wales.

Nögg. spatulata, Dan., and *N. media*, Dan., Upper Coal-measures (Newcastle beds), New South Wales.

Zeugophyllites elongatus, Morr.—At first described by Prof. Morris, from Tasmania, from the doubtful beds, which, however, from the evidence of *Thinnfeldia* (*Pecopteris*) *odontopteroides*, Morr., sp. (Fstm.), and *Sphenopteris elongata*, Carr., appear to be Mesozoic. Later, also found in New South Wales (in the Upper Coal-measures, Newcastle beds).

Cordaites australis, M'Coy, Devonian, Iguana Creek, Victoria.

Zamites (*Podoz.*) *ellipticus*, M'Coy, *Zam.* (*Podoz.*) *Barklyi*, M'Coy. *Zam. longifolius*, M'Coy, Upper Mesozoic beds in Victoria.

CONIFERÆ:—*Brachyphyllum australe*, Fstm. Upper Coal-measures (Newcastle beds), N. S. Wales.

Cardiocarpum australe, Carr., Upper Mesozoic, Queensland (Tivoli Mines).

The most important deductions are:

1. The doubtful strata in Tasmania (Jerusalem's Basin) are, from a palæontological point of view, equivalent with the Upper (Mesozoic) Coal-strata in Queensland, consequently also in N. S. Wales and Victoria.

2. *Phyllotheca*, which in Europe and Siberia is Jurassic, appears in Australia already in Palæozoic beds, and is found still in the Upper Mesozoic beds in Victoria.

3. *Glossopteris* appears in Australia in Palæozoic beds (for the first time with Lower Carboniferous plants), is most frequent in the Upper Coal-measures (Newcastle beds), continues in India and Russia into Jurassic beds.

4. *Nöggerathiopsis* begins in Australia in Palæozoic beds, and has a closely allied representative (*Rhiptozamites*) in the Jurassic beds in Siberia.

5. The Lower Carboniferous Flora of Port Stephens and Smith's Creek (Stroud), New South Wales, is of great importance for the knowledge of the geographical distribution of the Lower Carboniferous Flora.

III.—Further Notes on a Collection of Fossil Shells, etc., from Sumatra (obtained by M. Verbeek, Director of the Geological Survey of the West Coast, Sumatra). Part III.[1]

By Henry Woodward, LL.D., F.R.S., etc.;
of the British Museum.

(PLATES XII. and XIII.)

28. *Conus*, sp. (cast). Pl. XII. Fig. 1.

This cast indicates a subfusiform shell with a somewhat elongated conical spire, but the apex is imperfect: volutions contiguous and convex; the body-whorl gradually tapering to a somewhat acute base.

[1] Continued from the October Number, p. 444.

Dimensions:—Length about $3\frac{1}{2}$ inches; width of broadest part nearly $1\frac{5}{8}$ inch. Number of whorls 6–8.

This cone in its general form is evidently near to the *Conus Noe* of Brocchi (Conchiologia Fossile Subapennina, 1814, tom. ii. p. 293, tab. iii. fig. 3); but as it is only preserved to us in the form of a cast, it is impossible to do more than point out approximately its specific relations.

Formation:—Obtained by M. Verbeek from the bed marked (5), consisting of Tertiary Coral limestone, including internal casts of Gasteropods and Conchifers, etc. (Verbeek, Geol. Mag. 1877, p. 444).

Locality:—Government of the West Coast of Sumatra.

29. *Conus substriatellus* (cast), H. Woodw. Pl. XII. Fig. 2.

This cast—which approaches most nearly to *Conus striatellus* of H. M. Jenkins (Quart. Journ. Geol. Soc. 1863, vol. xx. p. 54, pl. vii. figs. 3*a*, 3*b*) from Java, and particularly with the figures of a cone referred to that species by Dr. K. Martin, in his work "Die Tertiär-schichten auf Java" (Univalves), Leyden, 1879, p. 9, tab. i. figs. 2 and 2*a*—represents a conical ventricose shell; the axis being short in proportion to its breadth; the whorls narrow, volutions 7–8 in number, apex depressed, aperture narrow, slightly dilated at the base.

Dimensions:—Height of shell 40 mm.; breadth of shell at widest part 28 mm.

The figure given by Mr. Jenkins is evidently that of a young individual, whereas our cast is that of an adult shell; Dr. Martin's figures represent three stages of growth, and his Fig. 2 most nearly corresponds with M. Verbeek's specimen.

It must, however, be borne in mind that the Javan fossils are represented by specimens having the shell preserved, whereas the Sumatran fossil is only a cast. I have therefore preferred to name it *C. substriatellus*.

Formation and Locality:—From the bed marked (5), found with the preceding species.

30. *Cypræa subelongata*, H. Woodw. Pl. XII. Fig. 3.

This species is represented by four examples, two of which have the shell partially preserved, which was tolerably thick; in general form it is somewhat amygdaloidal or ovato-elongate; the spire is slightly visible, but depressed; the aperture is narrow at the upper part, and somewhat dilated from the middle towards the base; there are well-marked indications of crenulations on the inner lip.

Dimensions: — Length of figured specimen 33 millimètres; breadth of shell $21\frac{1}{2}$ mm. The three other specimens referred to this species are somewhat smaller.

This shell closely resembles, in general form, the so-called *Ovula elongata* of D'Archiac (Descrip. des Animaux Fossiles de l'Inde, 1854, p. 331, pl. xxxiii. fig. 9 and 9*a*) from the Hala Chain; but as the Sumatran fossil affords distinct evidence of crenulations on the body-whorl, as above stated (although, unfortunately, our artist has omitted to indicate them in Fig. 3), we have not ventured to refer it to that species. Possibly—as the Indian shell is so like a *Cypræa* in general form—the artist of M. D'Archiac's plate may have in a similar manner overlooked the indications of crenulations on the body-whorl.

We have, however, considered it safer to refer this *Cypræa* to a new species, and have named it *C. subelongata.*

Formation and Locality:—Obtained with the preceding species.

31. *Cerithium,* sp. (casts of). Pl. XII. Fig. 4.

Our figure represents a cast of four somewhat convex volutions, very gradually increasing in size, and exhibiting traces of longitudinal ribs. Two other casts, probably belonging to the same species, indicate a considerably larger form. From their general character they no doubt indicate a species of *Cerithium*; but from their state of preservation, it is difficult to assign them to any particular species. They resemble somewhat the casts figured by D'Archiac (plate xxvii. fig. 13 and 14, p. 303, *op. cit.*) from the Nummulitic formation of India. These casts of *Cerithium* do not, however, exhibit any external indications of ribs. They might have represented the interior of *Cerithium Montis-Selæ,* K. Martin, plate xii. fig. 1 (Die Tertiärschichten auf Java, Leiden, 1879).

Formation and Locality:—Found with the preceding species.

32. *Turbo* (*Borneensis*? Böttger). Pl. XII. Fig. 5.

This is represented by the cast of a turbinated shell showing about four rapidly increasing very convex volutions, separated by a deep suture; portions of the shell remaining apparently indicate a thick and smooth test. Base umbilicated.

Dimensions:—Height of shell 36 mm.; breadth 36 mm. Thickness of body-whorl 19 mm. It seems probable that our specimen is closely allied to, if not actually identical with, the *Turbo Borneensis* of Dr. O. Böttger (Palæontographica: Beiträge zur Naturgeschichte der Vorwelt, Supplement III. Lief. I. 1875, 4to. p. 11, table i. fig. 3, *a, b, c,* and 4), obtained from the Nummulitic Limestone of Pengaron, Borneo, and also from the Tertiary formation of Sumatra.

This cast may also be compared with the *Turbo Pendjabensis,* D'Archiac and Haime (pl. xxvii. fig. 2, *op. cit.*), from the Tertiary Calcareous Marl, Punjaub, India.

Formation and Locality:—Found with the preceding species in bed marked (5), by M. Verbeek.

33. *Turbo,* sp. (*not figured*).

There are two other casts of a much larger form, probably belonging to the same genus, indicating a more discoidal shell, the body-whorl being much expanded, and the spire more depressed, the shell having also fewer whorls and a larger umbilical cavity.

Dimensions:—Height $1\frac{1}{4}$ inch; breadth $2\frac{1}{2}$ inches.

Formation and Locality:—Found with the preceding.

34. *Phasianella Oweni,* D'Archiac, 1854. Pl. XII. Fig. 6.

An oval elongated shell composed of 6–7 somewhat convex volutions, that increase very regularly and are separated by a well-marked suture. The aperture is subovate and the shell is not umbilicated; body-whorl equalling in length the height of the spire.

Dimensions:—Actual height of shell 33 mm. (Height of shell with the spire restored, about 41 mm.) Breadth of body-whorl 25 mm.

This species is represented by two casts which agree closely with the *Phasianella Oweni*, D'Arch. (pl. xxvii. fig. 3, *3a*., D'Archiac and Haime, Animaux Fossiles de l'Inde, p. 293), from the Nummulitic Limestone of the Hala Chain, and the compact Chalk-marl of the Salt-range, Punjaub.

It presents also some slight resemblance to the figures given by Dr. O. Böttger of his *Buccinum Pengaronense* (Palæontographica: Beiträge zur Natur. der Vorwelt. Suppt. III. Lief. I. 1875, taf. ii. fig. 11*a*., b. p. 16), from the Nummulitic Limestone of Pengaron, Borneo, and the Eocene formation of Sumatra; but the form of the aperture differs.

It might also be compared with Dr. K. Martin's *Natica Bandongensis*, K. Martin, p. 82, tab. xiii. fig. 15 (but not fig. 16), Die Tertiärschichten auf Java, 4to. 1879, from the Tertiary beds of Java.

Formation and Locality:—The same as that of the preceding species.

35. *Trochus*, sp. (casts of). Pl. XII. Fig. 7.

This species is represented by three casts. Shell trochiform, with six flattened volutions gradually increasing in size with a distinct suture, and ornamented with from 6 to 7 longitudinal ribs, broader than the spaces which separate them: base expanded, umbilicus deep and conical.

This shell presents some points of resemblance to the *Trochus radiatus*, Gmel. (see Dr. K. Martin, Die Tertiärschichten auf Java, 1879, Lief. I. p. 72, tab. xii. fig. 16); but the outer surface not being preserved in our specimens, it cannot be compared satisfactorily with this or allied forms.

Formation and Locality:—The same as the preceding species.

36. *Prenaster*, sp. Pl. XII. Fig. 8*a*, 8*b*.

The diagram of an Echinoderm on our Plate (Figs. 8*a*, *b*.) was transmitted with the collection to Prof. T. Rupert Jones, F.R.S., and submitted by him to Dr. Wright, F.R.S. His note has since been mislaid; the diagram-figure on the Plate only serves therefore to record its occurrence in the Sumatran Tertiaries.

In a letter lately received from Dr. Wright, he observes:—"In the absence of the specimen, I cannot venture to give a definite opinion about M. Verbeek's Echinoderm. If my memory serves me, when I first saw the diagram, I concluded that it was a Miocene Urchin differing from any that had been figured as coming from Java, and it reminded me of a form I had described from Malta belonging to the genus *Prenaster*,[1] which comprehends ovoid Urchins with inflated tests, having the ambulacral summit very excentric; the petaloid ambulacra slightly depressed, nearly level with the surface, and very divergent; often almost perpendicular; the anteal sulcus is

[1] This observation is extremely interesting, as M. Verbeek had already noticed in Geol. Mag. 1877, p. 444, under head of bed 5, the occurrence of "casts of Gasteropods and Conchifers, together with *Echinidæ*, comparable with the Eocene forms *Prenaster alpinus*, Desor, and *Periaster sub-globosus*, Desor," which Dr. Wright's observation tends to confirm.

nearly obsolete. The form I figured as *Prenaster excentricus* resembles the diagram-sketch on your Plate more than any other species that occurs to me now, so that your Sumatran Echinoderm may be an allied form belonging to the genus *Prenaster*. More than this I cannot say."

37. *Conus Niasensis*, H. Woodw. Pl. XIII. Fig. 1.

Shell conical-elongate, concentrically-striated, striæ wider apart towards the base of shell and rather more strongly accentuated; spire conical, apex obtuse, showing about seven volutions, concentrically striated and crenulated, the outer margins ornamented with a series of flattened tubercles; aperture narrow.

Dimensions:—Height 15 millimètres; breadth at widest part of shell 6½ mm.

The ornamentation of the upper portion of the whorls around the apex presents a close agreement with *Conus acutangulus*, Chemn., as figured by K. Martin from Java (Die Tertiärschichten auf Java, p. 11, tab. ii. fig. 2); but the apex of this species is more regularly conical and the shell itself is more robust.

Dr. Böttger also figures a cone under the name of *Conus gracilispira*, Böttg., from Pengaron, Borneo (p. 18, taf. ii. fig. 13, 14 *a*, and *b*, Palæontographica, 1875); but the apex is too truncated, and the specimen, being a cast, cannot be compared certainly with our fossil.

Formation:—Tertiary Grey Marl.

Locality:—Hiligara, Island of Nias, Government of the West Coast of Sumatra.

38. *Oliva mustelina?* Lamarck. Pl. XIII. Fig. 2 *a*, *b*.

The specimen figured consists only of the body-whorl, the apex being wanting; the shell is much eroded, and it would be difficult of identification, but it presents a great similarity to the *Oliva mustelina*, Lamarck, which is commonly met with on the coast of Japan, the Philippines, and Singapore.

The following is the description of *Oliva mustelina* (from Sowerby's *Thesaurus Conchyliorum* (1871), part xxx. p. 22).

"Shell oblong-cylindrical, subtruncated at both ends, thick; colour greyish yellow, marked with obliquely-longitudinal undulating lines; spire short, broad, suture acute, punctated; columella plicated throughout, terminating posteriorly in a thick elevated callus, having a few very strongly-oblique plicæ in front; aperture violet within; lip thick, elevated behind, interior and exterior smooth."

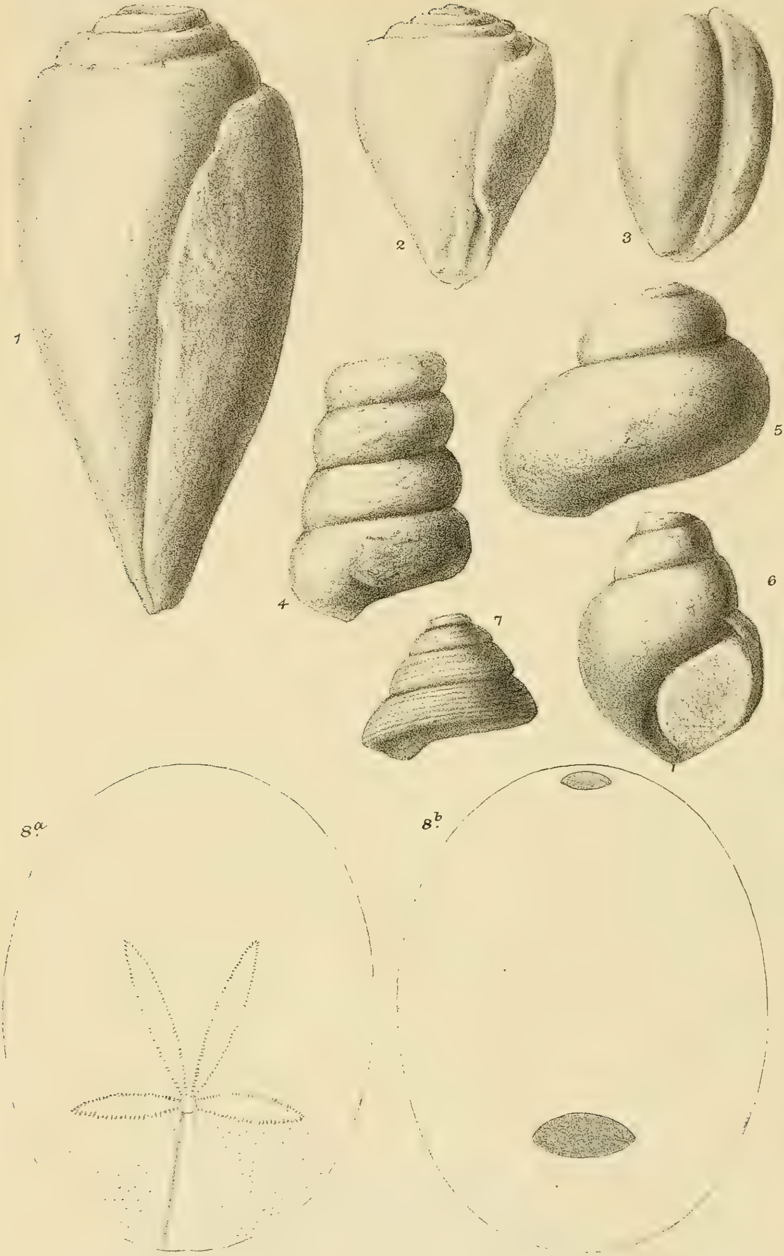
Formation:—(Sub-fossil?)

Locality:—Government of the West Coast of Sumatra.

39. *Oliva pseudoaustralis*, H. Woodw. Pl. XIII. Fig. 3.

This is a smooth ovate shell with a conical spire, and having a strongly ribbed columella which is thickened towards the base. It appears to be allied to the *Oliva australis* of Duclos, but it is rather shorter, and has a more conical spire.

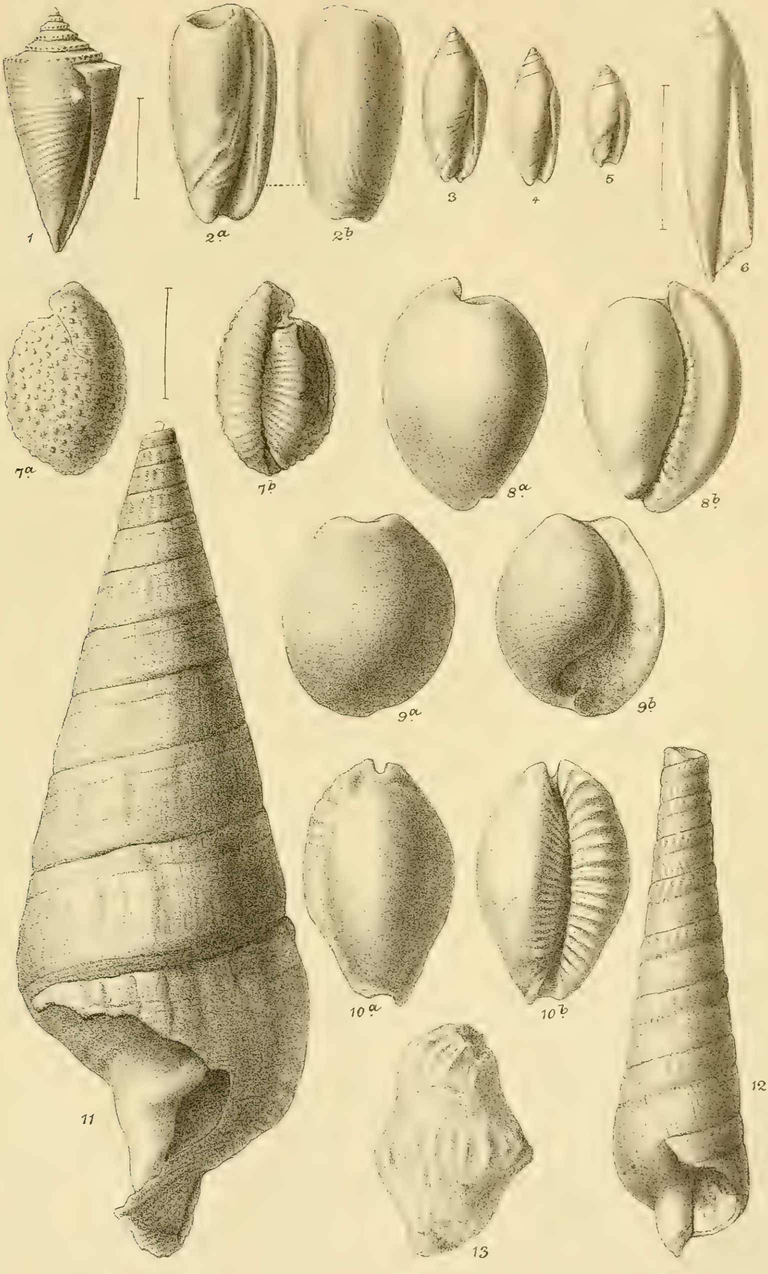
This species may also be compared with the *Oliva Javana*, K. Martin, (*op. cit.*) tab. iii. fig. 8 and 8*a*, but the spire of this latter species is more acute.



C. L. Griesbach del. et lith.

West, Newman & Co. imp.

Sumatran Tertiary Fossils.



C. L. Griesbach del. et lith.

West, Newman & Co. imp.

Sumatran Tertiary Shells &c.

Dimensions:—Length 20 mm.; greatest breadth 10 mm.

Formation:—From Grey Tertiary Marl-clay.

Locality:—Island of Nias, Government of the West Coast of Sumatra.

40. *Oliva pupæformis*, H. Woodw. Pl. XIII. Fig. 4.

This is a more attenuated and cylindrical shell than the preceding, with a produced and pointed spire, the columella having only two folds upon it. The aperture of the shell is narrow. Although resembling several small living species, yet upon close comparison it appears to be distinct.

Dimensions:—Height 18 mm.; breadth 7 mm.

In general proportions it agrees very nearly with Sowerby's *Oliva pupa*, from Soomrow, Cutch (Trans. Geol. Soc. 1840, vol. v. 2nd series, pl. xxvi. fig. 32).

Formation:—From Grey Tertiary Marl-clay.

Locality:—Island of Nias, Government of the West Coast of Sumatra.

41. *Ancillaria*, sp. Pl. XIII. Fig. 5.

This is a narrow cylindrical shell, with moderately wide aperture; columella with eight folds; marked by a broad and smooth band at the base; apex subacute.

Dimensions:—Height 14 mm.; breadth 6 mm.

Formation and Locality:—The same as preceding species.

42. *Terebellum*, sp. (cast). Pl. XIII. Fig. 6.

This narrow cylindrical form is destitute of any test, but from its general characters may very well be compared with the *Terebellum subulatum*, Chemnitz, a species distributed in the Indian Ocean, the Philippines, and the neighbouring seas of China, etc. The spire of the Sumatran fossil, however, is shorter, the sutures are less oblique, and the body-whorl near the spire is rather more tumid than in the recent form. (See Sowerby's *Thesaurus Conchyliorum*, vol. iii. 1866, pl. 218.)

Dimensions:—Height 20 mm.; breadth 5 mm.

Formation:—In light-coloured Tertiary Clay-marl.

Locality:—Island of Nias, Government of West Coast of Sumatra.

43 *Cypræa*, sp. (cast). Pl. XIII. Fig. 8*a*, *b*.

This is a smooth and polished cast of a short and very ovate and tumid *Cypræa*, which was probably not unlike the *Cypræa Reevii*, from Swan River. The spire seems to have been exserted; outer lip broad and marked by small but numerous teeth; the inner lip was also denticulated, especially towards the anterior end; the aperture is narrow near the centre, but expands somewhat towards each extremity.

Dimensions:—Length of shell 31 mm.; breadth 21 mm.

Formation:—In light-coloured Tertiary Clay-marl.

Locality:—Government of West Coast of Sumatra.

44. *Cypræa nucleus*, Linn. Pl. XIII. Figs. 7 *a* and *b*.

Shell (in living state) white, or reddish-yellow; ovate; produced at the extremities, elevated dorsally, irregularly tuberculate, with faint traces of ribs between the tubercles; base rounded, denticulations numerous, the intermediate ones diverging at margin of aperture, terminal ones distinct, divaricating; aperture narrow, dorsal cicatrix rather broad.

My colleague, Mr. Edgar Smith, having compared this fossil shell with the recent examples in the Collection, remarks: "Undoubtedly this is the *Cypræa nucleus*, Linn., whose geographical range extends from the Mauritius to the Philippines, Borneo, and the islands of the Pacific."

Dimensions:—Length of shell 15 mm.; breadth 9½ mm.; height 7 mm.

Formation:—In bluish Clay-marl (Miocene?), Tertiary.

Locality:—Island of Nias, Government of West Coast of Sumatra.

45. *Cypræa erosa*, Linn. Pl. XIII. Fig. 10 *a*, *b*.

Shell ovate-oblong, solid, somewhat depressed, colour (in living specimens) golden-yellow on the back, scattered over very commonly with minute white spots, more obscurely marked with a few chestnut spots; sides somewhat expanded and thickened, white at the extremities, marked by reflexed chestnut bands, and close-set crenulations; painted with a large dark-brown quadrate spot in the centre; base somewhat flattened, white, sometimes marked by puncta and converging lines of reddish chestnut. Aperture somewhat broad, expanded in front, bluish within; dentations 14 to 19 in number, short on the columella, prolonged on the lip; lip at the marginal terminations crenulated.

There is no doubt about this species, although subject to great variations. It occurs widely distributed, being recorded living from the Mauritius, Mozambique, Ceylon, Seychelles, Andaman Islands, North Australia, New Guinea, and several islands in the Pacific.

Dimensions of Fossil:—Length of shell 31 mm.; breadth 20 mm.; height 15 mm.

Formation:—In light-coloured Clay-marl (Tertiary).

Locality:—Government of West Coast of Sumatra.

46. *Bulla* (*Hydatina*) *crebristriata* (cast), H. Woodw. Pl. XIII. Fig. 9 *a*, *b*.

The cast of this shell shows it to have been roundly oval, umbilicated, the spire retuse; the surface closely and finely striated both longitudinally and transversely. Aperture wide near the umbilicus, and decreasing to one-half the width near the spire.

Dimensions:—Height of shell 24 mm.; greatest breadth 23 mm.

The nearest analogue to our fossil is to be found in the *Bulla physis* of Linnæus from the Mauritius (see Sowerby's Thesaur. Conch. 1855, vol. ii. p. 565, pl. cxx. fig. 9), but the aperture is wider in the recent shell. *B. physis* is also similarly striated.

It may also be compared with the *Bulla vexillum*, Chemnitz (Sowerby, Thesaur. Conch. *loc. cit.* pl. cxx. figs. 12–14), from Ceylon.

Being a cast, however, it is difficult to relegate it to any existing species.

Formation:—In light-coloured Tertiary Clay-marl.

Locality:—Government of the West Coast of Sumatra.

47. *Pyrazus palustris*, Linn. Pl. XIII. Fig. 11.

Shell large, pyramidal (colour brown in living examples), whorls straight, longitudinally plaited, and spirally distantly sulcated, interstices flat, aperture (*broken* in fossil) subquadrate, canal short, outer lip produced in front of the canal below. (The outer lip of the fossil shell is, however, broken.) Operculum not preserved—but in living shell spiral, with the whorls fluted.

Habitat:—This specimen is identical with the recent *Pyrazus palustris*, of Linnæus (see Reeve's *Conchologia Iconica*, vol. xv. genus *Pyrazus*, May, 1865). A very common species found in salt-marshes at the mouths of rivers, in the Eastern Archipelago, in Ceylon, in North Australia, and other localities.

Dimensions of fossil:—Height 4 inches; greatest breadth 1½ inches.

Formation:—(Subfossil?)

Locality:—Government of the West Coast of Sumatra.

48. *Terebra subacuminata*, H. Woodw. Pl. XII. Fig. 12.

Shell elongated, turriculated, very tapering, solid, with simple closely-united and numerous whorls, only a little rounded, and with but slightly indented sutures. Each whorl, at a distance of one-third of its breadth below the suture, is circumscribed by a single indented line, or fold,[1] parallel to the suture, and equally as clearly marked, which follows the course of the whorls of the shell from the apex to the aperture.

The shell is ornamented with numerous fine obliquely-curving parallel raised lines, the curvature of which is reversed above the indented line or fold. Aperture (broken) very small in proportion to the shell, elongated and deeply emarginated at the base. Columella simple, curved, with a single fold near the base. Nine whorls of our Sumatran fossil only are preserved, giving a length of 2½ inches. If the spire were restored, the length would have been about 4 inches.

This specimen approaches very closely to many recent forms of *Terebra*, but it differs from each in some minor points of form, ornamentation, or growth. It presents considerable affinity to *Terebra duplicata*, a species common to China and Singapore, but the costæ are much more strongly marked than in the fossil. *Terebra Lamarckii*, from Zanzibar, may also be compared with it, but the ornamentation in the living shell is too coarse. In *Terebra senegalensis* and in *T. pertusa* the parallel striæ agree better with our fossil, but in the former, the rate of increase of the shell is greater; whilst in the latter the ornamentation follows a different curve.

Its nearest fossil analogue appears to be found in the *Terebra acuminata*, Borson (Saggio di Oritt. Piem. Mem. della Accad. di Torino. t. xxv. p. 224, t. 1, fig. 17; and Hörnes, Die Fossilen Mollusken des Tertiaer-Beckens von Wien, 1856, Bd. i. p. 130, taf. 11, figs. 22, 23, 24, *a*, *b*), but the cincture or fold is less distinct and nearer to the suture than in M. Verbeek's specimen. The ornamental lines or striæ agree very nearly with *T. acuminata*.

[1] This indentation, or fold, reminds one of the similarly situated line or fold marking the position of the filled up slit, or notch, near the suture in the lip of *Pleurotoma*; there is no slit in the lip of *Terebra*, but in the recent *Terebra duplicata* the lip is slightly indented.

I have ventured, however, to consider this fossil as distinct, and have named it *Terebra subacuminata.*

Formation:—From Tertiary Grey Marl-clay.

Locality:—Government of the West Coast of Sumatra.

49. *Cœlosmilia?* Pl. XIII. Fig. 13.

An imperfectly preserved Coral with the habit of growth of a *Cœlosmilia.*

EXPLANATION OF PLATES XII. AND XIII.

PLATE XII.

Fig. 1. *Conus*, sp. (cast), Tertiary Coral Limestone, Government of the West Coast of Sumatra.
„ 2. *Conus substriatellus*, H. Woodw., Gov. of the West Coast of Sumatra.
„ 3. *Cypræa subelongata*, H. Woodw. „ „
„ 4. *Cerithium*, sp. (cast) „ „
„ 5. *Turbo* (*Borneensis?* Böttger) „ „
„ 6. *Phasianella Oweni*, D'Archiac „ „
„ 7. *Trochus*, sp. (cast) „ „
„ 8. *Prenaster*, sp. „ „
a upper, *b* under side (Drawn from a Diagram.)

PLATE XIII.

Fig. 1. *Conus Niasensis*, H. Woodw., Tertiary Grey Marl, Hiligara, Island of Nias, Government of the West Coast of Sumatra.
„ 2 *a, b*. *Oliva mustelina?* Lamarck (subfossil?), Government of West Coast of Sumatra.
„ 3. *Oliva pseudoaustralis*, H. Woodw., Tertiary Grey Marl, Government of West Coast of Sumatra.
„ 4. *Oliva pupaformis*, H. Woodw., Government of West Coast of Sumatra.
„ 5. *Ancillaria*, sp. „ „
„ 6. *Terebellum*, sp. (cast). In light-coloured Tertiary Clay-marl, Ditto.
„ 7. *Cypræa nucleus*, Linn. Miocene Clay-marl, Island of Nias.
„ 8. ———, sp. (cast) „ „
„ 9. *Bulla crebristriata*, H. Woodw., Ditto, Government of W. Coast of Sumatra.
„ 10. *Cypræa erosa*, Linn. „ „
„ 11. *Pyrazus palustris*, Linn. (subfossil?) „ „
„ 12. *Terebra subacuminata*, H. Woodw., Grey Tertiary Marl. „
„ 13. *Cœlosmilia?* sp. „ „

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

IV.—The Age of the "Pennine Chain."

By E. Wilson, F.G.S.

The "Pennine Chain" is the name (restored about fifty years ago by Conybeare and Phillips from the "Alpes Penini" of the Romans) for that hilly tract of country that stretches from the borders of Scotland on the North to the centre of Derbyshire on the South. This important range possesses the structure of a great, though complex, anticlinal, the result of a meridional movement of upheaval that took place at a remote period in the physical history of our island. This axis of elevation, which ranges a little west of North through North Derbyshire and West Yorkshire, throws off the Coal-measures of Yorkshire and Derbyshire on the one side, and those of Lancashire and North Staffordshire on the other, with a steeper dip on the West, and a gentler inclination on the East. The maximum of this upheaval is attained in North Derbyshire, where a dome-shaped mass of Mountain Limestone has been exposed at the surface at an altitude of 1500 feet above the sea.

In many ways this prominent feature in the physical structure of our island is worthy of notice. It has had a great deal to do with the distribution of the mineral wealth of the North of England, and if, as one result of that elevation, a vast amount of valuable Coal-measures have been swept away, still many mineral substances of great economic value have been brought within our reach, that would otherwise have been hopelessly buried in the bowels of the earth; while we are at the same time indebted to this ancient earth-movement for that bold and beautiful scenery, moorland and mountain, scar and dale, that characterizes the Pennine Chain in its range through the counties of Derby and York. It is not, however, from an economical or an æsthetic, but from a physical point of view, that I propose to consider this ancient mountain chain. In particular I seek to arrive at its age.

The age of the Pennine Chain has long been a matter of doubt and debate among physical geologists. While all are agreed that the upraising of this great anticlinal took place before the Triassic epoch, the question still remains whether it was or was not also Pre-Permian. In 1861, Prof. Hull stated his belief that the Pennine Chain was elevated into land *during* the deposition of the earlier Permian strata.[1] In 1868, however, the learned Professor had come to the conclusion that this earliest upheaval took place between the close of the Permian period and the commencement of the Trias, "that it belonged to that period of general stratigraphical disturbance which marked the close of the Palæozoic age."[2] As a rule, geologists appear to have been content to follow in the wake of so high an authority.[3] Several years ago my local rock studies in the adjoining county of Nottingham led me to believe that the Pennine Chain was older and not younger than the Magnesian Limestone, and subsequent observations have tended to fortify me in that opinion. Let us first, however, examine what is to be said in favour of the opposite view.

The chief, if not the only item cited by Prof. Hull in support of a Post-Permian upheaval, is the *supposed* identity in origin (in Lancashire, Cheshire, and Staffordshire) of two important lines of fracture respectively known as the Anticlinal Fault and the Red Rock Fault.[4] The Anticlinal Fault and the Red Rock Fault run meridionally (approximately) parallel with each other and with the Pennine Chain. Professor Hull, therefore, concludes that all three were the results of a common movement: The Anticlinal Fault near Leck passes under Bunter (conglomerate) without faulting that rock, therefore this common movement was Pre-Triassic; the Red Rock Fault near Stockport faults Permians, consequently this common movement was Post-Permian. But,

[1] Quart. Journ. Geol. Soc. vol. xvi. p. 63.

[2] Quart. Journ. Geol. Soc. vol. xxiv. p. 323. Triassic and Permian Rocks, p. 111. Coal-fields of Great Britain, 1873, p. 468.

[3] Geol. Mag. 1872, p. 389; 1879, p. 110; West Yorkshire, p. 9; President's Address to Geological Section, British Association Meeting, 1879.

[4] Quart. Journ. Geol. Soc. vol. xxiv. p. 323.

the same Red Rock Fault elsewhere, viz. near Macclesfield and Congleton, displaces Upper Keuper rocks. To get over this difficulty, then, Professor Hull assumes that the Red Rock Fault is the result of *two* independent displacements, the first Pre-Permian, the second Post-Triassic. To this style of reasoning I object: in the first place, that it is unphilosophical to base an argument on assumptions; in the next place, that on the hypothesis of two movements for the Red Rock Fault, the failure of participation in the second of such movements by the Anticlinal Fault shows that faults may run parallel to one another and to great anticlinals without being contemporaneous; and lastly, that on the assumption that the Red Rock Fault, the Anticlinal Fault and the Pennine Chain *were* coëval, and that the Red Rock Fault *has* undergone a second displacement, there is yet no evidence to show that it was not the *second* of such movements that for the *first* time faulted the Permians near Stockport and that the earlier displacement of the Red Rock Fault was, with the Anticlinal Fault and the Pennine Chain, Pre-Permian. Having now disposed of the theory of a Post-Permian origin of the Pennine Chain, I proceed to the consideration of the evidence I have been able to gather together in favour of a Pre-Permian upheaval.

I. The great Yorkshire Coal-basin was evidently formed before the commencement of the Permian period, for all along the eastern borders of the exposed portion of the Coal-field, wherever the Coal-measure strata are seen to pass under the Magnesian Limestone, the easterly dip of the Coal-measures is more or less evidently greater than that of the Permians. Now, as the North and South axis of the Coal-field runs parallel with the Pennine axis, we may safely assume that these had a common origin. Consequently the Pennine Chain is also Pre-Permian. In some magnificent sections, recently opened out by railway extension at Kimberley, near Nottingham, the Middle Coal-measures may be seen dipping north-east at angles varying from 5° to 10° or 15° beneath Permians (Marl-slate, and Lower Magnesian Limestone) that dip east at about 1°. In consequence of this greater inclination of the Coal-measures, any particular seam of Coal is found at constantly increasing depths going east. The "Top Hard" or Barnsley seam, for instance, which, at Kimberley, is only 284 feet below the Permians, is 630 feet beneath the same at Cinderhill, two miles to the east. Again, this Coal at Clowne is 890 feet deep, but at Steetley, which lies about three miles further east, it is 1590 feet down to it. "All along the edge of the escarpment of the Magnesian Limestone," says Prof. Hull, "and for a short distance beyond, in Notts and Derbyshire, as far North as Rotherham, the Coal-seams are found to dip eastward at a greater angle than the Limestone itself, which (with the Lower Red Sandstone) rests unconformably on the Coal-measures."[1]

II. The Marl-slates, slowly but surely, alternate in a westerly direction as if approaching a margin. In some recent unsuccessful

[1] Coal-fields of Great Britain, 3rd edition, 1873, p. 245.

explorations for Coal at South Scarle, Lincolnshire, the Permian rocks proved to be much more developed than in West Notts. At Scarle the Lower Magnesian Limestone and Marl-slates together amount to a thickness of 219 feet, at Bestwood to 95 feet, and at Kimberley to from 53 to 33 feet only, while west of the Erewash no Permians are found, and Triassic rocks repose directly on various members of the Carboniferous formation.

III. Coincidently with this attenuation the Magnesian Limestone becomes intermingled with sedimentary materials on the west. The Lower Magnesian Limestone, though no thicker on the east than on the west, is a very different rock. Under Lincolnshire, it is a pure cream-coloured compact limestone; while in West Notts it is instead a coarse granular dolomite, interleaved with seams of marl and micaceous sand, and may become gritty, and even conglomeratic. These phenomena would seem to indicate the shallowing of the waters, and the vicinity of land on the west in Zechstein times.

IV. Mountain Limestone pebbles are said to have been found in Permian rocks on the east, and certainly occur in Permian breccias west of the Pennine Chain. The basement Permian breccia of Notts is largely composed of the debris of Coal-measure rocks. Such fragmental materials could only have been derived from the denudation of a central tract of land composed of Carboniferous rocks in Permian times, and clearly indicate not only that the Pennine Chain had come into existence in Pre-Permian times, but also that denudation had supervened to such an extent, that rocks so low down as the Mountain Limestone were then laid bare in that range.

V. Though the Bunter Sandstone of West Notts and East Derbyshire contains numerous fragments of Carboniferous rocks,—Limestone, chert, and Millstone Grit,—no fragments of Permian rocks are to be found in that or any other member of the Trias. This fact, though negative, and therefore inconclusive, would seem to show that the Permians were formed subsequently to the elevation of the Pennine Chain, and consequently were not uplifted so as to be exposed to denudation on the flanks of that range in Triassic times.

VI. The absence of Permian outliers, at any distance west of the Magnesian Limestone escarpment, taken in conjunction with the absence of fragments of Permian rocks in the Triassic rocks of the neighbourhood, indicates that the original margin of the Magnesian Limestone waters did not lie very far west of the present escarpment.

VII. There is no similarity either in character, thickness, or succession of the Permians on the opposite sides of the Pennine Chain. In Lancashire and Cheshire the Lower Permians are represented, according to the Government Surveyors, by a mass of unfossiliferous red sandstone, estimated to attain a maximum of 1500 feet (near Stockport), while the Upper Permians of South Lancashire consist of from 100 to 250 feet of red calcareous marls with thin bands of earthy limestone and gypsum.[1]

[1] See Geological Survey Memoirs of the district.

Omitting from consideration the "Lower Permian Sandstone," the true horizon of which seems doubtful, we still find a very dissimilar grouping of the Permians on the two sides of the Pennine Chain. In Lancashire and Cheshire we look in vain for any deposit answering to the highly characteristic Marl-slates of the North-east of England, nor do we find any considerable masses of dolomite comparable with those of Yorkshire and Durham. From Notts to Northumberland the Marl-slates, Magnesian Limestone, and Upper Marls are severally distributed, but on passing across England from Notts to Lancashire—a much less horizontal distance—we find that we cannot positively recognize one of these members of the Zechstein. This marked dissimilarity is in part at least to be accounted for by the presence of an intervening land-barrier—the Pennine Chain.

We may then, I think, without hesitation, conclude that the elevation of the Pennine Chain took place before the commencement of the Permian epoch, or at any rate prior to the deposition of the Permian rocks of the North of England.

I have already called attention to some of the results of the elevation of this important range. Its influence on the distribution of the rock masses of the neighbourhood, which began in early Permian times, persisted into the Keuper epoch. Having in Pre-Permian times acquired the elevation and stability of an arch, this great and complex anticlinal still maintains that relative superiority to the surrounding country that has justly earned for it the epithet of the "Backbone of England." Though marine denudation has planed away its top, while subaërial decay has cut deeply into its framework, the great hardness and extreme durability of its more axial rocks has enabled this ancient anticlinal to resist these agents of destruction so successfully that it still forms a broad elevated tract of country, while rearing its loftier peaks from two to three thousand feet above the sea.

V.—Note on an Olivine Gabbro (Forellenstein) from Cornwall.

By F. T. S. Houghton, B.A.,

Scholar of St. John's College, Cambridge.

In Quart. Journ. Geol. Soc. 1877, pp. 906, *et seq.*, Prof. Bonney describes a Gabbro from Coverack, on the eastern coast of the Lizard peninsula, which he remarks bears, macroscopically and microscopically, a close resemblance to the Forellenstein of Volpersdorf. In order to investigate further the nature of the rock, I made, at his suggestion, an analysis of it. The piece selected had proved on microscopic examination to be almost free from pyroxenic constituents. No. I. was decomposed by fusion with alkalies. No. II. by hydrochloric acid. The residue in this case was white, and probably consisted of undecomposed felspar, showing that at any rate it was not all anorthite. No. III. is an analysis of the Volpersdorf rock quoted by Zirkel (Lehrb. der Petrog. ii. 139).

	I.	II.	III.
Water	4·38	3·96	8·30
Silica	45·73	44·81	41·13
Alumina	22·10	21·62	13·56
Ferric Oxide	0·71	0·86	2·19
Ferrous Oxide	3·51	3·73	6·19
Lime	9·26	9·19	6·72
Magnesia	11·46	11·78	22·52
Potash	0·34	0·35	0·83*
Soda	2·54	2·30	0·96
Residue	——	3·17	——
	100·03	101·77	102·40

* This proportion of Potash and Soda hardly agrees with that given in the analysis of the felspar (2).

From a comparison of these analyses, the two rocks would appear, at first sight, to be of very different natures; but on examining the results, it is seen that, whereas the Cornish rock contains only 33 per cent. of olivine, the Volpersdorf has 45 per cent.; a difference in proportion quite observable under the microscope.

There being this great difference in the proportion of the minerals, it remained to determine the composition of the felspar. A sufficient quantity, freed as much as possible from olivine, was submitted to analysis with the result detailed in No. I. No. II. is an analysis of the felspar of the Volpersdorf rock quoted by Zirkel (*loc. cit.*).

	I.	II.
Water	3·19	1·87
Silica	49·65	47·05
Alumina	29·35	30·44
Iron Oxides	0·59	1 56
Lime	12·18	16·53
Magnesia	0·46	0·09
Potash	0·48	0·78
Soda	3 61	2·10
	99·51	100·42
Oxygen ratios	1 : 3 : 5·7	1 : 2·7 : 4·5

This gives a composition for the felspar of the Cornish rock of

$$11\ \{Al_2O_3.\ CaO.\ (SiO_2)_2\} + 3\ \{Al_2O_3.\ Na_2O.\ (SiO_2)_6\}$$

Anorthite Albite

which is an excess of two molecules of anorthite over that necessary to form labradorite. The felspar thus proves to be—like that of the Volpersdorf rock—not a true anorthite, but possibly a decomposed labradorite, which has lost some of its alkalies; this being suggested by a slight excess of silicate of alumina over and above that required by the formula above given. Vom Rath suggests a similar origin for the felspar of the German Forellenstein. We may, therefore, without hesitation, place the Cornish rock among the Forellensteins—adding another locality to the few already known for this rock.

VI.—Further Notes upon the Form of Volcanos.[1]

By John Milne, F.G.S.,
Professor of Geology and Mineralogy, Imperial College of Engineering, Yedo, Japan.

During the last summer I made a journey from Yedo as far north as the southern end of Kamschatka.[2] As when upon this trip I saw and visited many volcanos in Yezo and the Kuriles, I venture to offer a few remarks in addition to those which I have already expressed upon the form of this interesting class of mountains.

In the Geological Magazine, August, 1878, I endeavoured to show that the sides of all regularly-formed volcanos are not straight slopes, but have a curvature which in form is logarithmic. This form, it was pointed out, was that which would be assumed by any heap of loose materials such as those out of which we may suppose a volcano to be built. From this it was inferred that these regular volcanos were natural forms, and not forms which had been produced by the wearing away of one part and the bolstering up of another, as we find spoken of in treatises on volcanos and physical geology. It was also pointed out that from the external form of a mountain it might be possible to calculate the dimension of any internal core.

To illustrate these views, I used several profiles traced from a series of photographs of two volcanos.

From the volcanos which I have subsequently seen in Yezo, the Kuriles and South Kamschatka, I see that my views were very poorly illustrated, and had I the means when there of obtaining other profiles, I feel that the case stated in the above-mentioned paper might be more satisfactorily demonstrated. In looking at the illustrations which I have given, it will be observed that some of my curves, although generally logarithmic in character, are by no means absolutely so. By comparing the curves of each profile it will be seen that the discrepancy in the fourth column is greatly due to not having had any true method of fixing an axis, and it would have been better to have taken the mean of each pair of ordinates and treated the two sides of a profile as a single curve.

Another point to be observed is, that if the logarithmic curve drawn for purposes of comparison had been placed on profile No. 4 rather than upon profile No. 2, it would have been seen to have a nearer coincidence with the curvature of the mountain.

Notwithstanding these misleading illustrations, the logarithmic character of the curvature is clearly to be recognized.

Similarity in curvature.—When in the Kuriles, I saw many beautifully formed volcanos, and these, almost one and all, showed a slope which, so far as I could judge, was similar to that upon the mountains which have been shown to have a logarithmic curvature. Unfortunately I was unable to take an outline of these mountains which, for purposes of geometrical measurement, would be of any value. All that I can say is that these contours appeared to have a general

[1] For my previous paper, "On the Form of Volcanos," see Geol. Mag. 1878, Decade II. Vol. V. pp. 337—345, Plate IX.

[2] See Geol. Mag. 1879, Decade II. Vol. VI. p. 337, Pl. IX.

character, and that this character was similar to what I have already described.

One confirmation of this identity I find by reference to my sketches. Another confirmation was obtained whilst taking the angular distance between several of these mountains by means of a sextant held horizontally. By this I was enabled to carry the reflected image of one mountain and place it in juxtaposition with the image of its neighbour, the latter being seen directly. Whenever this was done the similarity in the curvature of the two mountains was very striking. Experiments of this sort were made at several places. The first were made along the north-west shore of Paramushir, where there are a number of extremely well-formed mountains. The only one of these which bears a name is Mount Fuss. Another well-formed mountain is the Island of Alaid.

Curvature of hills, piles of debris, etc.—Curvatures which appear to be similar to those we see upon the sides of volcanos are to be seen upon the slopes of many hills. These are especially noticeable upon the surface of debris lying beneath steep scarps. These curves are, however, seldom to be observed. The reason is that it is only rarely we can obtain their profile view. In looking at a range of hills, we usually see them curving downwards towards the low ground, and if we ascend them we usually remark that the climbing becomes more difficult the higher we go up. When the slope of hills like these can be looked at from the end of the range instead of from the front, a peculiar curvature will be observed, and this is not unlike the logarithmic curvature of volcanos. Profile views of curvatures are strikingly exhibited upon the sides of Hakodate Head. This is a solitary mountain at the south end of Yezo, upon which the town of Hakodate is built. Its position and its shape make it very like Gibraltar. It consists of a mass of trachytic rock covered with alluvium. Near the top of the mountain, which is more than 1,100 feet in height, the alluvium is thin, but near the base it is many feet in thickness.

From its nature it is to a large extent evidently the result of the degradation of the rocks on which it rests. Materials from high levels have been constantly rolling to low levels, larger stones rolling farther than smaller ones, and the consequence has been that from the base to near the summit long curvatures have been formed. As the mountain is a solitary one, these curvatures can be seen in profile, and their form is remarkably like that exhibited by volcanos.

Experiments upon the form of heaps.—In order to determine the form which a heap of loose material assumes, I made several experiments by allowing a stream of sand and gravel to fall through a funnel upon a level floor. The heaps which were produced were as follows:—

1. *Fine sand.*—This fell from a height of about 3 feet until it formed a heap 27 inches high. The sides appeared to be straight, and they had a slope of 31° 30′.

2. *Fine gravel.*—This fell until it formed a heap 21 inches high. The sides of this were also straight, and the slope was 31° 30′.

3. *Fine gravel mixed with sand.*—This fell to form a heap 26 inches high. Round the base a slight curvature was observed.

4. A mass of gravel mixed with sand was formed by throwing it against a board, on which a sheet of paper had been stretched. Here also a slight curvature was obtained, which was marked off upon the paper.

Taking these experiments as a whole, it will be observed that I did not obtain much evidence in favour of my views. In experiments number 3 and 4, where slight curvatures were obtained, it must be noticed that I was using a material the particles of which were of *different sizes.* Had the experiments been upon a larger scale, I think the results might have been more satisfactory. Also, if the sand and gravel, instead of falling in a column, had fallen as a rain upon the heap, and the heap had subsequently been left some months to settle, the curvatures would in all probability have been more decided.

By allowing water to fall for some time as a light shower over the heaps, I endeavoured to imitate the effects of denudation. Although many of the showers were infinitely greater in proportion to the size of my heaps than the showers of rain which fall upon a mountain are to the mountain and its materials, the dragging of materials to the base was not sufficient to produce any observable curvature. This would seem to show that it is not denudation of a kind like this to which we must turn in order to find an explanation for the curvatures of volcanos.

In looking at any large heap of materials, the component parts of which are of *different sizes,* a curvature will, I think, be always observed.

A short time ago I observed this upon a number of heaps of gravel, which, for purposes of measurement, had been piled in large rectangular cases. These cases had subsequently been removed, and the heaps left to themselves. First, the sides had fallen downwards and outwards, the larger stones rolling the farthest, and a curvature had been produced. Since the first general form had been assumed, a similar action had been slowly going on under the combined influence of gravity, and, to a slight extent, the weather.

These heaps were about 3 feet high. Their curvature was best observed by standing at a distance, and then stooping until you brought your eye on a level with the heap.

As the result of these experiments and observations, I would classify the principal causes which tend to affect the form of a volcano under the following three heads :—

1st. Causes tending to give a volcano its characteristic curvature.

a. The tendency of a self-supporting heap under the influence of its own weight to spread outwards at the base. This would tend to give a logarithmic curvature.

b. The tendency during the building up of a mountain of the larger particles to roll farther than the smaller ones. This will also depend on the specific gravity, the porosity, etc., of the particles thrown out during an eruption. We may regard this action as extremely rapid denudation carried on by gravity.

c. Denudation by weather and gravity. This tends to efface a mountain by digging away materials from the top and making its steepness less and less. At the bottom of the mountain, where denudation is also going on but at a slower rate than it takes place near the top, these materials are deposited and spread out.

It must here be noticed that on a volcano, and especially near its summit, material is seldom to be found lying at an angle which is *less* than its angle of repose. Of this fact I have convinced myself that it is the case upon the slopes of many volcanos; 1st, by observing that the materials on any particular slope were uniform in size; and, 2nd, that if upon such a slope I dropped a piece of material larger than those of which the slope was made, it commenced to roll towards a lower level.

If this be granted, then the levelling action of denudation cannot have played a very important part in giving the form to a volcano; otherwise we should expect to find materials lying at angles *less* than that which a heap of them would naturally exhibit. However, denudation must have had some effect, and as this effect will probably have been nearly the same on all sides of the mountain, it will not materially affect its regularity.

2nd. Causes principally affecting the regularity of a mountain.

About these I have written before. Briefly they are as follows:—

1. Position of the crater. If this is central, we should expect the mountain to be regular.
2. Lateral and parasitic craters will tend to destroy the regularity.
3. Direction of the wind during an eruption.
4. Nature of the eruptions. If these have been paroxysmal, and have blown away portions of a crater,—if lava has flowed on one side more than on another, etc., we have causes tending to destroy regularity.

3rd. Causes partially affecting the form of a volcano, but principally its height.

The movement of the strata upon which a volcano is built.

As has been pointed out by Mr. Mallet, the weight of a volcano may tend to crush the strata on which it rests so as to form a saucer-shaped depression. Round the bottom of the mountain the ground may be caused to rise.

Evisceration or honeycombing beneath a mountain may also cause a depression to take place.

I would also suggest that because it is probable that during the period of activity, which is a length of time to be measured by many years, the rocks beneath the protective covering which has been built above them must become extremely hot, and the mountain will have an augmented height due to the expansion of the beds upon which it rests. When the activity becomes less intense, contraction sets in, and a sinking may take place.

To form any accurate idea of the effect which may be produced by any action of this description is very difficult. If we think of the small amount of heat which passes through the bricks of a furnace, we might suppose that the conduction of heat from the heated nucleus of a volcano into the surrounding rocks would be too small to produce any appreciable effect, whilst if we think of the rapidity with which heat travels through a glass into which we pour hot water, we might arrive at opposite conclusions. The rate at which heat flows through rocks is a subject of which we have little or no personal experience, and about which we cannot therefore form any *primâ facie* opinion.

To give some idea of what actually must take place, the case of an infinite mass of rock heated from a plane surface of constant temperature has been taken as the simplest case for which calculations can be made. The temperature of the plane is taken at 2000° Fahr.; and the time during which conduction has taken place at 2000 years, the object being to find the temperature at various distances from the hot plane in the surrounding rock. We might consider the hot surface to be spherical or a vertical cylinder, but the simple case of a plane surface kept constantly at a high temperature is easier to calculate, and at the same time sufficiently illustrates my idea.

If the isothermal surfaces are parallel planes, and x is measured at right angles to these planes, then an element of rock of unit area and thickness dx, if it is at a temperature v at the time t, receives heat when increasing in temperature dv;—

C.D. dv. dx in the time dt, where *C.D.* is the capacity for heat of the rock.

But through one face it receives heat by conduction in the time dt, and through the other face it loses by conduction, and the difference is—

$$K.\frac{d^2v}{dx^2}\, dx.\ dt.$$

K being the conductivity, and hence—

$$C.D.\ \frac{dv}{dt}\ dx = K\ \frac{d^2v}{dx^2}\ dx$$

$$\frac{dv}{dt} = \frac{K.}{C.D.}\ \frac{d^2v}{dx^2}$$

The initial conditions are that where $x=0$, the temperature v is constant; when $t=0$, then $v=0$ everywhere except where $x=0$, and the above equation leads under these circumstances to the result—

$$-\frac{dv}{dx} = \frac{V_0}{\sqrt{\pi kt.}}\ \epsilon^{\frac{-x^2}{4\,kt}}$$

This equation cannot be integrated in finite terms, but the following table of values for $-\frac{dv}{dx}$ has been calculated; t being 2000 years, K as equal to 400 in Foot, Year, Fahrenheit units,[1] and V_0 the temperature of the melted rocks which fill the plane fissure, being at least 2000° Fahr.

[1] For this value I am indebted to the experiments of Professors Perry and Ayrton, "On the Conductivity of Stone," Phil. Mag. 1878.

x in feet.	$-\frac{dv}{dx}$
0	1·2500·
500	1·1560·
700	1·0690·
1000	0·9140·
2000	0·3580·
3000	0·0751·
5000	0·0005·

A curve was drawn with these numbers as co-ordinates, and it is evident that the area of this curve up to any value of x is the difference between the temperature at that point and 2000° Fahr. In this way the following table showing the temperature at various distances from the hot surface was obtained.

Distance from Hot Surface in feet.	Rise of Temperature Produced in 2000 Years.
0	2000° Fahr.
600	1275° ,,
800	1062° ,,
1000	862° ,,
1200	667° ,,
1400	548° ,,
1600	423° ,,
1800	321° ,,
2000	244° ,,
2200	178° ,,
2400	129° ,,
2600	92° ,,
2800	64° ,,
3000	45° ,,

On looking at these results, it will be observed that they are far greater than might have been anticipated. Perhaps it may be objected that the conditions which have been taken as compared with those which occur in nature have been overrated. I think quite differently.

First, 2000 years is hardly an overestimate of the length of time during which a volcano may remain in activity. Vesuvius is recorded as having erupted in the year A.D. 79, and it still continues in activity. Before that time it was a recognized volcano, but how many thousands of years it may have been in existence we do not know. In Ischia and neighbouring places there were eruptions 400 years previously. All that we can say is that, as evidenced by the large amount of ejected matter which was in existence before the eruption of 79, it was even then a mountain of some antiquity.

Secondly, a temperature of 2000° Fahr. for molten matter, such as that about which we speak, is an estimate which is extremely low.

Sir William Thomson, in his calculations relative to the age of the earth, takes the temperature of molten rocks from 7000° to 10,000° Fahr., but these temperatures are purposely taken as large as possible. Bischof, in his "Geologie," p. 98, takes as the melting point of lava 2250 °Fahr.

When speaking of this temperature, it must be remembered that it is not supposed to exist in molten rocks near the surface, but in rocks beneath the base of a volcano, which at their central parts are buried beneath a mass of material equal to the height of the volcano, which will usually be many thousands of feet. And just as the water at the bottom of an Icelandic geyser is hotter than that near the surface, so we may expect the rocks of which we speak to have an augmented temperature.

Another condition is that of the heated plane. From what is known of the internal structure of a volcano, a central column terminating in a crater above, and provided with many branches ramifying through the mass of the volcano, would be a truer representation of the actual conditions than those which have been taken. These ramifications would probably be continuous into the ground beneath, and deep down it is not at all unlikely that they converge towards a highly heated nucleus from which all the molten matter emanates. If these are anything like the conditions beneath a volcano, and I see no reasons why they should not be, then the plate of heated matter is but a very feeble representative of the heating surfaces which actually exist.

The only point about which I think any doubt can be expressed will be relative to the length of time during which such a heating surface may be imagined to retain a constant temperature. Whilst a volcano is in actual activity, the temperature deep down beneath the crater probably remains constant far above 2000° Fahr., and during the intervals which fall between the eruptions, whilst the volcano is only perhaps giving out wreaths of vapour, it does not seem at all improbable that, if it were possible to take the temperature some thousands of feet below the crater from which the steam is issuing, we should also find a temperature far above 2000° Fahr.

It must be also remembered that the heating effect which takes place is over and above any original temperature which the rocks may be supposed to have had before any volcanic eruption took place.

On the whole, therefore, I think the conditions of the given case have by no means been overestimated, but rather, were we able to take the conditions which actually exist, we should find temperatures far above 2000° Fahr., acting over periods longer than 2000 years, and, what is more important, instead of heat being given off from a single plane, it would be found to be given off from a multitude of surfaces, and the effect dependent on these temperatures enormously exaggerated.

Confining one's self to the example which has been taken, it now only remains for us to consider what these effects might be.

In vol. ii. p. 238, Lyell, in his "Principles of Geology," says, "It was ascertained that fine-grained granite expanded with 1° Fahr. at the rate of ·000004825; white crystalline marble ·000005668; and red sandstone ·000009532, or about twice as much as granite. Now, according to this law of expansion, a mass of sandstone a mile in thickness, which should have its temperature raised 200° Fah., would lift a superimposed layer of rock to the height of ten feet above its former level. But suppose a part of the earth's crust fifty miles in thickness, and equally expansible, to have its temperature raised 600° or 800°, this might produce an elevation of between 1,000 and 1,500 feet. The cooling of the same mass might afterwards cause the overlying rocks to sink down again and resume their original position."

In the case we have been considering, we see that temperatures are produced far greater than those spoken of by Lyell, and consequently the effect will be correspondingly augmented.

But the effect produced by simple expansion is not all. The rocks distant from the heating surface will offer resistance to the expanding mass which lies between them, and cause it to elevate itself towards the centre, the action being not unlike that which is exhibited by the iron arch of a bridge when expanding on a hot day. In the bridge the rise is only perhaps one or two inches. To us this is almost imperceptible. But if the same fact could be communicated to a creature no larger than a fly which lived upon the bridge, it would seem to be immense. Similarly if we could only learn the height to which a volcano is elevated by the heat developed during its period of activity, we might be equally astonished; for, when reckoned in feet, it is probably very great.

So far we have only considered the heat beneath a volcano as an agent producing expansion, and consequently elevation. If we imagine the heat to be much greater than that which I have taken, it is possible that in certain tracts it might produce fusion or at least plasticity, the result of which might be that the pressing downwards of the superincumbent weight would produce depression. However, if such conditions have any existence, I fancy that their extent is limited; and anyhow, outside the plastic area there will be expansion and consequent elevation.

Results of elevation or depression.—As elevation or depression beneath a volcano, such as those of which I have been speaking, will, in all probability, take place so slowly, the effect cannot be expected to materially alter the form of a volcano, degrading influence tending to produce a natural form compensating sufficiently rapidly to outweigh the influence of these motions. The effect which will be produced is rather a change in height.

We have here perhaps in part the means of explaining why the measurements of the heights of certain volcanos when made at long intervals apart should have given different results.[1]

We may carry these ideas from a single volcano to a volcanic district. During periods of activity we should expect to find the heat gradients steeper than during periods of repose, and therefore during such periods of maximum temperature, elevation might be expected. Also the rate at which the steepness of a heat gradient in a district varies might indicate the approach or recession of volcanic agency, and perhaps may even yet give us a measure of the time by which such actions are removed.

[1] I think that these discrepancies have been noticed and written upon in the "Geographical Magazine," October, 1877, but I have not the means of making reference.

Conclusion.—In this, and a preceding paper already referred to, I have endeavoured to point out, firstly, what are the actual forms of certain volcanos, and secondly, the principal causes which produce and subsequently modify these forms.

Taken as a whole, these causes are very varied in their character. If we examine them singly, we can but barely form an idea as to the nature of their actions, and when we remember that, not only are they irregular in themselves, but that they act irregularly in their relations to each other, we see that the task of unravelling their complications becomes quite hopeless. In cases like this mathematical investigation helps us to obtain a clearer idea of an action, but it is seldom that it can be made to measure it. All that we can do is to fall back upon opinions, observations, and common-sense, the ordinary weapons which build up or destroy geological hypotheses.

NOTICES OF MEMOIRS.

I.—Coal and Iron in South Africa.[1]

(From the "Friend of the Free State," etc., Bloemfontein, August, 7, 1879.)

THE following extracts from Mr. G. W. Stow's Geological Report on the Orange-River Free State show what immense supplies of coal and iron-ore await the arrival of the miner in that region :—

Taking the road to Rietvlei, before reaching the homestead of Fieldcornet Stoffel Bosman, the old partially metamorphosed sandstones[2] are again met with, cropping up above the surface. Here they are pinkish-white, fine-grained, and dip to the W.S.W. at an angle of 54° to 55°. The most important feature connected with their appearance at this spot is the great beds of iron-ore associated with them. These become distinctly visible immediately in the rear of Mr. Bosman's house. I was first struck in finding fragments of these ferruginous rocks employed in building portions of the fences round the land and kraals. Once upon their trail they are easily traced for miles. At one spot, about a couple of miles from the homestead, three beds are most clearly exposed. They are as follows :—On the top of a high bank the first bed is exposed on the surface for a breadth of about sixty feet, with a westerly dip of about 60°; about 450 feet from this a second bed makes its appearance, with a surface exposure of 45 feet, continuing towards a lower bank on the right about 750 feet distant; a third, but smaller, bed next crops out, with a surface exposure of about 25 feet. The dip of these last is similar to the first. These beds, therefore, run parallel one to another, and are regularly interstratified with the sandstones. The true thickness of the respective beds is : first bed, 50 feet; second bed, 40 feet; third bed, 20 feet; making a total thickness of 110 feet. A considerable quantity of magnetite, or magnetic iron-ore, is found in them, which quickly makes itself

[1] Kindly communicated by Prof. T. Rupert Jones, F.R.S.

[2] See Quart. Journ. Geol. Soc. vol. xxx. p. 624, etc.

known by its influence on the compass. In a mile's length, the two largest of the iron-ore beds must contain in a breadth of 300 feet on the surface of the plain a mass of ore equal to 5,280,000 tons; in a breadth of 600 feet, a mass of ore equal to 10,560,000 tons; in a breadth of 1,000 feet, a mass of ore equal to 17,555,000 tons or 52,800,000 tons at 600 feet in a length of five miles.

Outcrops of these beds show themselves at intervals as far as the farm Klipdrift, on the banks of the Lower Rhenoster River, a distance of more than fifteen miles. There is, therefore, every reason to believe that they are continuous for that distance.

The value of iron-ore, delivered at the smelting furnace, is about £1 per ton; but, however large the quantity of iron-ore may be, it is valueless unless fuel can be obtained for smelting within a convenient distance. Thus, the excellent iron-ore in Griqualand-West is unavailable at present for this reason. That of the Free State is found under more favourable circumstances. The outcrop of these metalliferous rocks on the high ground, near Klipdrift, is within a few miles of a sixteen-inch seam of coal cropping out near that river-valley at two separate places, both above and below where the iron-ore is found. While the greater outcrop at Rietvlei is within 20 or 30 miles of the great coal-bed, and so situated that any train or railway which may hereafter be constructed for the conveyance of the coal to such great centres of consumption as the Diamond Fields, must of necessity pass within a very few miles of the place where the largest quantity of iron-ore is exposed, and will thus bring the fuel and the ore almost into juxtaposition. This is an advantage which cannot be over-estimated; but I must leave others to decide the important bearing a discovery of this kind must have upon the posperity of the State, when these buried treasures are properly utilized, and the inhabitants avail themselves of such resources.

Mr. Stow, F.G.S., reports that the following useful materials occur in the Free State:—

1. Nodular limestone, such as used in other countries as cement-stone, scattered over various parts of the State.
2. Great beds of old crystalline limestones (siliceo-calcareous rocks).
3. An immense area of country filled with porphyritic rocks, which would vie with granite for durability and beauty.
4. An abundant supply of magnetic and other rich iron-ores, within a convenient distance of the necessary fuel for smelting.
5. A great coal-bed.

In a former report he stated that, judging from the excavations made in the Sand River district, the coal underlying that portion of the country would, at a low estimate, amount to some 145,800,000 tons. We can now safely state that in the new coal-field, since discovered in the Vaal River valley, the minimum quantity would be some 350,000,000 tons; making a total, in the two coal-beds, of 495,800,000 tons, which, at five shillings a ton, would represent a money-value of more than £123,900,000. If, however, instead of taking a minimum quantity, we take an average, we should find, even leaving the Sand River coal out of the calculation, that in the Vaal River coal-bed alone there must be some 1,225,120,000 tons awaiting the miner—a quantity of coal which, at the same low rate as that before mentioned (5*s.* per ton), would represent a value of £300,000,000.

From calculations based on those used in England, Mr. Stow finds that the Free State coal-supply would be sufficient to allow of a yearly consumption of more than 6,000,000 tons for a period of 1,200 years!

It is not improbable that, as great outcrops of coal in this portion of South Africa show themselves in the Free State, along the Vaal Valley, and also in the Transvaal, west of the Drakensberg, associated with the rocks dipping eastward, and as they again appear in the Utrecht Division of the same province, as well as at Biggarsberg (Newcastle) in Natal, to the east of the same great range, these are all parts of the same great coal-field; the Drakensberg mountains occupying their synclinal trough. If, after proper investigation, such should prove to be the case, the supply of South-African coal will be enormous, throwing the figures above quoted, vast as they appear, completely in the shade.

The Free-State coal has not yet been analyzed; but, as a rule, the amount of "ash" in this South-African coal is much greater than that imported from Europe. Some of the duller kinds leave "clinkers" when burnt; but all those I have tried, says Mr. Stow, give out an intense heat. Mr. North, the Colonial Engineer, in his excellent Report upon the subject, considers that with specially constructed furnaces and movable fire-bars, the objections raised against Cape coal may be overcome; while Mr. A. N. Ella, who consumes large quantities of fuel for steam-purposes, considers that a ton (of 2000 lbs.) of Indwe coal at 40*s.*, would be cheaper than two loads of firewood at the same price, besides the labour saved in chopping up the latter.

In the present Report Mr. Stow has not touched upon the additional scientific knowledge gained during this geological survey; but the facts collected fully bear out, he believes, the deduction to which he was led by a study of similar rocks in Griqualand-West.

Although much work has been done, a reference to the map of the Report will show that much of the Free-State has yet to be examined; and it is to be hoped that the completion of this important Survey will be fully carried out.

II.—Description de deux nouveaux genres de Crinoïdes du terrain Dévonien de la Mayenne, par M. D. Œhlert. (Bull. Soc. Géol. de France, 3e. série, t. viie. pp. 6–10.)

INTERCALATED with the beds of shelly Devonian Limestone at La Baconnière, Saint-Germain and Saint-Jean (in the Department of Mayenne), are some layers of black schist. These schists contain but few fossils, the following, excepting the subjects of this paper, being the only species yet found:—*Spirifer Rousseau, S.*

lævicosta, Terebratula sub-Wilsoni, Chonetes sarcinulata, Tentaculites Velaini, and a few Polyzoa.

The Crinoidal remains that M. Œhlert has been so fortunate as to discover in these beds are, he thinks, sufficiently complete to establish the existence of two new genera, each represented by a single species.

For these our author proposes the respective names of *Thylacocrinus Vannioti* and *Clonocrinus Bigsbyi.*

The genus *Thylacocrinus* comes nearest in its formulæ to *Rodocrinus*, Miller, and *Eucrinus*, Angelin; whilst *Clonocrinus*, we are told, greatly resembles Angelin's figure of *Melocrinus spectabilis.*

This last-named species M. Œhlert is inclined to consider has been erroneously referred by Angelin to the genus *Melocrinus* as founded by Goldfuss, and he ventures to suggest that it might, perhaps, be more properly classed as another species of this new genus, *Clonocrinus*. (The Plates are not given.) B. B. W.

REVIEWS.

I. — The Geology of New Hampshire. By C. H. Hitchcock, State Geologist, and Assistants. Vol. II., Part 2, Stratigraphical Geology; Vol. III., Part 3, Surface Geology; Part 4, Mineralogy and Lithology; Part 5, Economic Geology. Accompanied by a Folio Atlas of Maps and Illustrations. (Concord, 1877–78.)

THESE two volumes, published in 1877–78, conclude the report on the Geology of New Hampshire, and give the results of the exploration of that State, under the direction of Mr. C. H. Hitchcock. Filling more than 1,200 pages, they contain a detailed account of the geology of the different districts of the State, preceded by a brief notice of the relations of the geology of New Hampshire to that of the adjacent territory. The second volume, on the Stratigraphical Geology, is mostly due to the labours of Mr. Hitchcock, chapters ii. and v. and parts 3 and 4 being supplied by his assistant, Mr. Huntington. There are no formations in the State of later date than the Lower Helderberg, save the surface deposits. The stratified groups comprise in descending order—1. The Cenozoic,—include the glacial and modified drifts, about 450 feet. 2. Palæozoic,—Lower Helderberg, Coös group and Cambrian Slates, 15,800 feet. 3. Strata doubtfully referred to the Palæozoic, 11,600 feet. 4. Eozoic, comprising, Upper Huronian, 12,129 feet, Labrador system, Montalban, 11,370 feet, Laurentian, 34,900 feet.

The Labrador system is in very limited amount, and recent investigations make it difficult to say that the Labrador rocks are not of eruptive character, and whether (as at Waterville) they really represent the Labrador system of Canada. With regard to the Montalban rocks, Mr. Hitchcock differs from Dr. Sterry Hunt as to their position, and from the observations of the former we are led to the view that they *underlie* and not *overlie* the Huronian, though the precise relationship is not beyond controversy (p. 669). The eruptive masses consist of various kinds of granitic, felspathic, and augitic rocks.

The third volume will probably be found of more interest than the second, as under the head of "Surface Geology" there are two important chapters on the Glacial period, and associated phenomena of New Hampshire, which are perhaps as well shown there as in any part of the earth. The first, by Mr. W. Upham, treats fully of the observations made by him in the different districts, and includes the "Lower Till" deposited during the Glacial period, and found throughout the State. This is succeeded by the Upper Till, and the Champlain period, which embraced the time occupied by the final melting of the great ice-sheet, during which the abraded materials contained in the ice-mass were washed away and deposited as kames, kame-like plains, and valley or modified drift; these were followed by the recent or terrace period, during which deep and wide channels were excavated in the Champlain deposits; a table is given showing the formations which have been described in the chapter, arranged in the order of their deposition (p. 176).

The general characters of the glacial drift are also further described by Mr. C. H. Hitchcock, who treats, amongst other points, of the causes of the glacial cold, of interglacial deposits, and the length of the Glacial period, concluding with his most recent opinions on the order of events occurring in New Hampshire, in the Glacial, Champlain, and subsequent periods.

The Glacial period of the northern hemisphere has been a subject of considerable attention among geologists and physicists, and various theories have been suggested to account for the cause of the glacial cold, but none have been universally accepted. Every additional information tending to enlarge our knowledge of the origin, extent, and movement of the ice-sheet, as fully indicated for New Hampshire by Mr. Hitchcock, will be usefully consulted by those interested in the subject.

Part 4 contains a description by Mr. G. W. Hawes of the minerals and rocks of the State, illustrated by eleven plates showing their microscopic structure. Part 5 gives an account by Mr. Hitchcock of the localities, modes of occurrence, and quantity of materials valuable for economic purposes, as metals and their ores, building materials, and natural fertilizers.

The vast amount of information systematically arranged in these volumes, on the physical features, agricultural character, geological structure, and economical products, will be of great advantage to those persons more directly interested in the natural resources of the State. But the value of the descriptive portion is further enhanced by the fine folio atlas which accompanies the work, containing two topographical maps of the State, in the years 1784 and 1816; a large map showing the geological features and position of the mines in the Ammonoosuk mining district, the details of which are given in vol. ii. p. 272; a series of panoramic views and camera profiles, illustrating the contours of many picturesque parts of the country; five maps showing the position of the modified drift and direction of the glacial striæ so fully described in vol. iii. (chapters 1 and 2); besides a geological map in six sheets, clearly illustrating the description of the stratified and other rocks given in the second volume. This map, while indicating the results of the labours of the State Geologist and his colleagues during their explorations, will, besides its local interest, facilitate the comparison of the geological features of New Hampshire with those of the surrounding territories. J. M.

II.—Special Report on the Trap-dykes and Azoic Rocks of South-eastern Pennsylvania. By T. Sterry Hunt. Part I. Historical Introduction. (Harrisburg, 1878.)

THIS work forms the first portion of a special report by Dr. Hunt on the Azoic Rocks, Trap-dykes, and Iron Ores of Pennsylvania. It contains an Introduction to the Geology of South-eastern Pennsylvania, an account of the Cambrian Rocks of Europe and America, and three chapters (II. III. V.) on American Pre-Silurian Geology, which comprise an historical and critical review of the progress of our knowledge bearing on the older rocks of North America, during the last sixty years,—from the publication of Maclure's map in 1817, until the present time. It would be impossible to condense satisfactorily, in this brief notice, the opinions and descriptions of the various writers cited throughout the work, which Dr. Hunt has himself so concisely and clearly treated, as well as interspersed many suggestive remarks, on the characters, origin, and sequence of the Azoic rocks, considered to be of Pre-Palæozoic age, and which are also fully noticed in his Chemical and Geological Essays. As, however, the recent researches of Dr. Hicks and others in this country (see Geol. Mag. *ante*, p. 433) have shown certain crystalline rocks to be of Pre-Cambrian age, it may be useful to give the results of the recent studies of Dr. Sterry Hunt on the older rocks of Eastern North America, including the Lake Superior region. These terranes are, in descending order, as follows:—

8. Siluro-Cambrian.—The Upper Cambrian of Sedgwick, part of the Lower Silurian of Murchison, and of the Matinal of Rogers.

7. Cambrian.—The Lower and Middle Cambrian of Sedgwick, the Lower and Upper Cambrian of Hicks; the Upper Taconic of Emmons, and the Quebec group of Logan; the Primordial, and part of the Lower Silurian of Murchison.

6. Keeweenian.—The Copper-bearing series of Lake Superior, found in the same geological interval as the Taconian, but not identified with it.

5. Taconian.—The Lower Taconic of Emmons, including a part of the Primal, Auroral, and Matinal divisions of Rogers, and constituting, with the Montalban, what was once called Terranovan by the writer.

4. Montalban.—The White Mountain or Mica-schist series.

3. Huronian.—The Green Mountain series, or altered Quebec group of Logan.

2. Norian.—The Labradorian, or Upper Laurentian of Logan.

1. Laurentian.—A lower division, the Ottawa Gneiss, and an upper division, the Grenville series, between which is a supposed unconformity. These two constitute the Lower Laurentian of Logan.

With regard to the five lower terranes, they have, notwithstanding their differences, certain lithological resemblances with each other. "All of them include quartzites, and crystalline limestones, in which certain mineral silicates, such as serpentines, hornblende, and micas, are occasionally met with. It is in those aluminiferous rocks which are without lime and magnesia, that are found the essential and characteristic differences, and these depend upon a progressive diminution in the proportion of the alkalies to the alumina, as we pass from the older to the newer geognostical groups" (p. 210).

The above classification is different from the opinions held by the author previous to 1871, as he maintained that the crystalline rocks of the Green Mountain and White Mountain series were altered Palæozoic sediments, but which he now considers to be of Pre-Cambrian age.

Some of Dr. Hunt's views given in the report are not in accordance with those of Pennsylvania geologists of the first or second surveys, and although the State Geologist (J. P. Lesley) feels "it is somewhat premature to dogmatise about the Taconic system; as it is impossible yet for any competent judge to express a positive opinion respecting such terms as Montalban, Norian, etc., in Pennsylvania," yet he fairly acknowledges "that a debt of gratitude is due to Dr. Hunt for this historical monograph, which will supply a deeply felt deficiency in the literature of our science." J. M.

III.—The Post-Tertiary Deposits of Cambridgeshire. By A. J. Jukes-Browne. 8vo. pp. 85. (Cambridge, Deighton, Bell & Co., 1878.) Price 2*s.* 6*d.*

In 1876 the Sedgwick Prize was awarded to Mr. Jukes-Browne for an essay on "The Post-Tertiary Deposits of Cambridgeshire and their relations to deposits of the same period in the rest of East Anglia." This with some few additions is here reproduced, and is so neat in form and moderate in price that our Geological Survey authorities might well take a lesson from it.

Commencing with some historical notices on the study of drifts in general, the author proceeds to review the various works dealing with the tract he describes—from the time of the Rev. Professor Hailstone in 1816 to the date of his own publication. After a brief account of the physical features of Cambridgeshire, he turns at once to the description of the Glacial Beds. These include the Chalky Boulder-clay, usually classed as Upper Glacial, and certain gravels. Mr. Jukes-Browne considers that the Boulder-clay was accumulated during the period of most intense glacial cold, and he would not exclude other beds from the glacial series simply because they happen to lie above this particular clay.

No deposits of Lower or Middle Glacial age are recognized by him in the area, for although here and there certain sands and loams are interposed between beds of Boulder-clay, he regards this feature as probably the result of contemporaneous current action. Brief mention is made of the great boulder of Gault and Chalk seen in the celebrated pit at Roslyn Hole, and which has been described in detail in Prof. Bonney's "Cambridgeshire Geology," and in Mr. Skertchly's "Geology of the Fenland."

The "Hill Gravels" are next described; these overlie the Boulder-clay, where it occurs, and contain many fragments derived from it. Much of the gravel is described as coarse and unstratified. Succeeding these in point of time are the "Valley Gravels of the Early River System." These are similar in composition to the Hill Gravels, but are entirely separated from the Glacial deposits. While they appear to have a distinct relation to the valley systems in which they lie, yet in their lower prolongations in the Cam Valley they stretch away almost at right angles to its present course. Still their fluviatile origin remains conspicuous. The March gravels which form little islands in the Fenland are described with these valley gravels, although they contain marine shells. Their connexion is not discussed. Prof. Bonney and Mr. S. V. Wood, jun., hold them to be coeval with the older (*Cyrena fluminalis*) gravel of Barnwell.

The "Valley Gravels of the Present River System" are then described; the first determination of the waters towards which is marked, according to Mr. Jukes-Browne, by the series to which the Barnwell gravels belong.

A short chapter is devoted to the correlation of the Cambridgeshire drifts with those of the Eastern Counties. Mr. Jukes-Browne is not satisfied with the evidence brought forward by Messrs. Wood and Harmer to make an unconformity between the Lower and Middle Glacial deposits of East Anglia; indeed he suggests that the Cromer Till, Contorted Drift, and Middle Drift might be bracketed together as Lower Glacial; and the Chalky Boulder-clay and overlying Plateaux or "Cannon-shot" gravel, as Upper Glacial. This view, which considerably simplifies the geology of the Eastern Counties, is one in which we cordially agree.

From the title of the work it might have been expected that descriptions of the Alluvial strata of the Fenland would have been included; this, however, was considered to be beyond the scope of the subject proposed.

IV.—Amphibians from the Permian Rocks of Bohemia.[1]

Dr. ANTON FRITSCH, whose important works on the fossils of the Cretaceous formation in Bohemia are well known, has commenced to publish, with the assistance of the Imperial Academy of Vienna, a Fauna of the Coal and Limestone of the Bohemian rocks of Permian age, of which the first part is just issued. This monograph, which, when completed, will extend over three volumes, will rank as one of the most important modern contributions to Palæontology, on account of the large number of new and singular types of life which it describes and makes known by splendid illustrations. It is essentially a descriptive work, and the author treats his subject rather from the zoological point of view than that of the comparative anatomist.

[1] Fauna der Gaskohle und der Kalksteine der Permformation Böhmens, von Dr. Ant. Fritsch, A O. Professor der Zoologie an der Universität in Prag. Band I. Heft I. (Prag. 1879.)

This Fauna has been discovered during the last ten years, and in the preface a detailed account is given of the gradual augmentation of material, which comprises in all some forty-three species of Amphibians, thirty-three Fishes, and eleven Arthropodæ, besides a single shell of the genus *Anthracosia.* This first part consists of ninety-two pages of text, with many woodcut illustrations and twelve quarto plates. The work opens with an interesting geological description of the deposits which have yielded the remains. It describes with the help of excellent sections the structure of the Pilsen basin, giving some useful lists of the plant remains and other fossils, and then at less length describes the Schlan-Rakowitz basin: so that the horizons of the specimens are all accurately determined. To this memoir succeeds a systematic list of the species, giving an enumeration of the materials available for description. The next section of the work is called a history of the classification of Labyrinthodonts, in which the views of Owen, as stated in his Palæontology, and of Dawson, are briefly referred to; but the bulk of the article is a verbatim translation of Prof. Miall's two reports to the British Association upon the Carboniferous Labyrinthodontia; and in conclusion, the work of Prof. Cope on the American Amphibians, and of Prof. Gaudry on Protriton, is briefly noticed. This preliminary matter occupies the first sixty-seven pages. The remains described in the succeeding pages are all referred to Cope's order Stegocephali, which is co-extensive with the Labyrinthodontia, Ganocephala, and Microsauria, and defined by the supra-occipital and epiotic bones forming well-developed ossifications, by the temporal fossa being covered by the supra-temporal and post-orbital bones, by the presence of a parietal foramen, and by the lower pelvic elements being well developed. The genera now described are named *Branchiosaurus, Sparodus, Hylonomus,* and *Dawsonia.*

Branchiosaurus resembles the Earth-salamanders, and especially the young forms, in possessing gills, and the author remarks that the broad anteriorly rounded head, the short thick body, and the well-developed extremities terminating in digits, together with the rudder-like tail, strongly suggest the larval forms of the living *Urodela. Branchiosaurus salamandroides* is known from ten complete specimens, and fragments which may have belonged to fifty or sixty other individuals. The skeleton ossifies at an early period in life, and all the bones of the skull, vertebral column, and extremities are already defined in examples sixteen millimètres long. And in a somewhat larger individual even the sclerotic plates, ribs, and phalanges are distinctly seen.

The largest specimen of this species is 64 millimètres long. If Dr. Fritsch is right in referring all these remains to one species, they present the remarkable condition of the growth of the limbs remaining stationary while the body increases in size and length. Both the humerus and fore-arm are absolutely longer in the animal, measuring 44 millimètres, than in that which has a length of 64 millimètres, while in the hind-limb the bones are of equal length in both specimens.

The skin was dense, and its impression is preserved in most specimens, as may be seen in the subjoined and following figures.

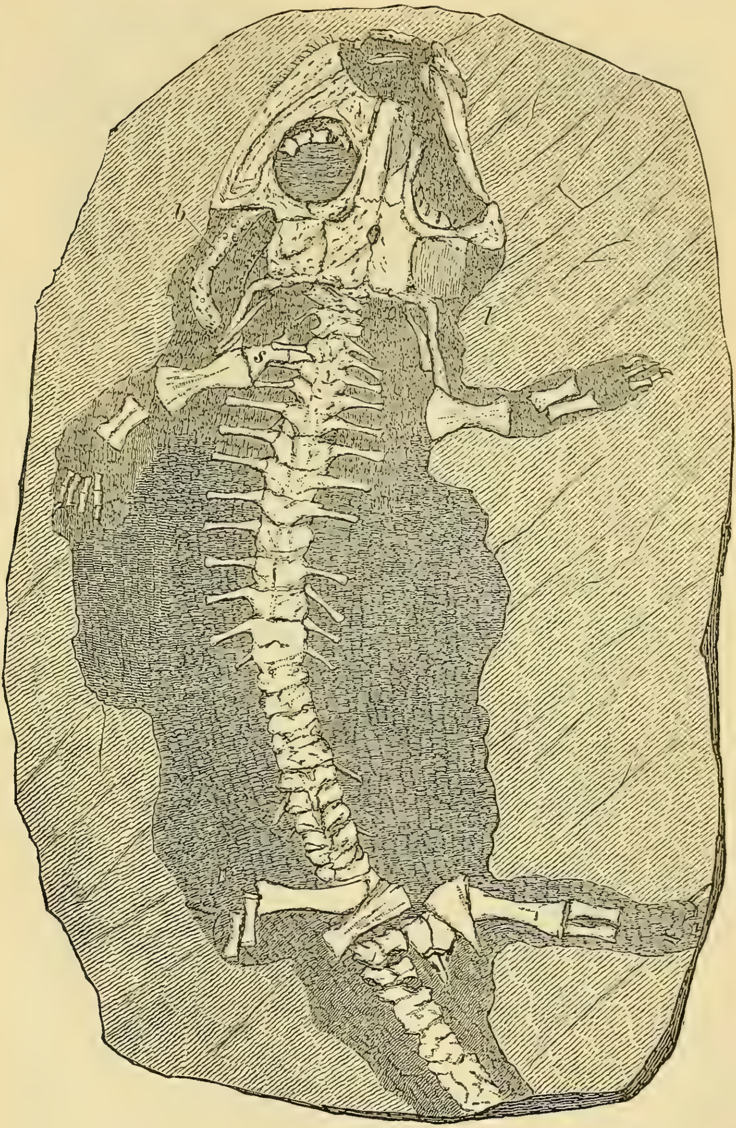


Fig. 1.—The largest example of *Branchiosaurus salamandroides*, Fritsch. Enlarged three times. Dorsal view.

When highly magnified, slight ridges are seen upon it; these are the first indications of scales, which become more developed on

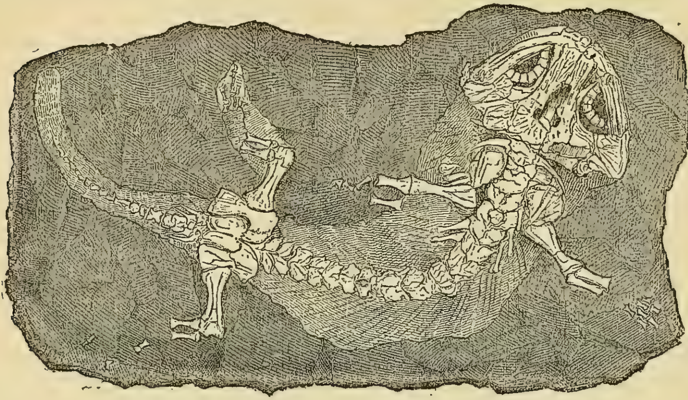


Fig. 2.—*Branchiosaurus salamandroides*, Fritsch.
Enlarged to twice the natural size.

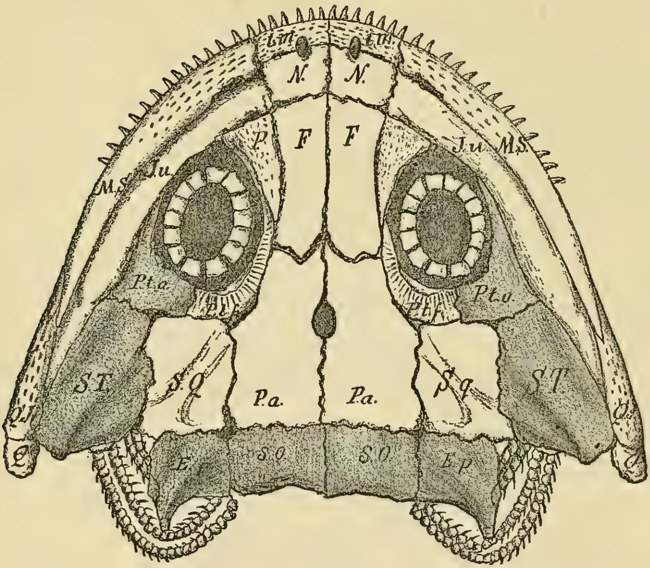


Fig. 3.—Upper side. Restoration of the skull of *Branchiosaurus salamandroides*, Fritsch. Enlarged six times.

the under-side of the body. The scales are ovate, truncated in front and somewhat irregular behind.

In the median part of the abdomen the scales are long, and assume a V pattern. The impressions of small rounded bodies seen in this region upon the scales are considered to be eggs.

The form of the skull and general relations of the bones will best be gathered from Figs. 3 and 4. The osteological details are given by the author at great length. The premaxillaries (im) are ornamented with delicate long pits, and carry from 6 to 10 short pointed teeth, which are larger than those in the maxillary bones and lower jaw; they are smooth and have a round pulp-cavity.

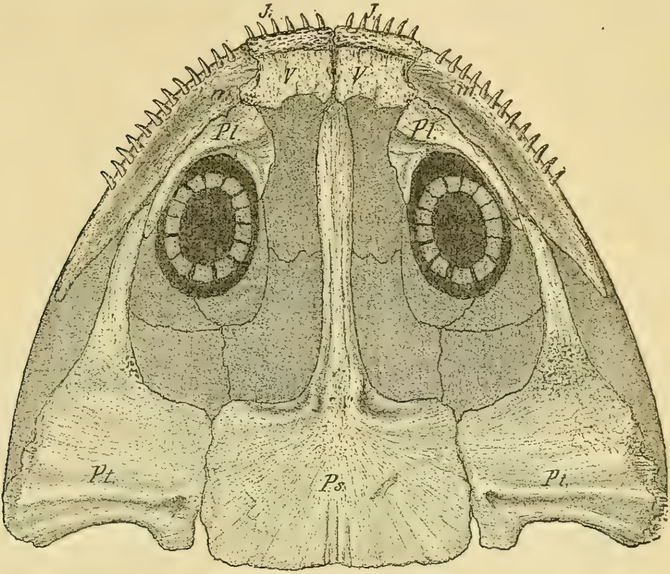


FIG. 4.—Under side of the skull of *Branchiosaurus salamandroides*, Fritsch. Six times natural size.

The maxillary (MS.), which is similarly pitted, and extends back to the quadrato-jugal (QJ.), carries from 10 to 18 teeth. There are probably two or three irregular rows of teeth behind these. The nasal bones (N.) are notched in front to form with the premaxillary bones the small nasal apertures, which they border on the inner side with an elevated ridge. The lachrymal bone is absent. The frontal bone (F.) is excluded from the circle of the orbit by the triangular prefrontal bone (P.) in front, and the sickle-shaped post-frontal bone (Pt. f.) behind. Its upper surface is covered with delicate long pits; and the post-frontal bone is strongly sculptured. The triangular post-orbital bone (Pt. o.) forms the outer and hinder border of the orbit. The jugal (Ju.) is a long bone which extends back from the nasal and parallel to the maxillary, so as to form part of the border of the orbit, and partly divide the quadrato-jugal (QJ.) from the supratemporal (S.T.). Between the parietal bones (Pa.) in the middle of the suture is the ovate or round foramen parietale, measuring a fifth or a sixth of the length of the suture. The Epiotic (Ep.) terminates backward and outward in a strong free process; it bounds the ear. In the outer edge of the supra-temporal bone (S.T) is often a notch, which may indicate the outer opening of the ear. The quadrate bone (Q.) is very small. The supra-occipital (S.O.) is well developed; but the exoccipitals cannot be determined with certainty, though they may form the occipital condyles. The under-side of the skull, Fig. 4, is remarkable for the large size of the palatal apertures, which are defined by the parasphenoid bone (Ps.) in the middle, by the pterygoids (Pt.) at the outer sides, and by the palatine bones (p) in front. As in some living *Urodela*, there is a small aperture in the sutural line between the vomers (V.). There are traces of small groups of teeth on the hinder and outer edges of the vomerine bones.

The lower jaw always becomes attenuated anteriorly. It consists of three bones, articular, angular, and dentary. The latter element carries a row of about 20 large smooth teeth.

The sclerotic circle is made up of about 14 oblong plates, which are marked with concentric lines.

On each side of the hinder part of the skull are two branchial arches which carry two rows of strong spheroidal bones, each bearing a little curved spine.

The vertebral column is divided into back and tail. From the head to the pelvis there are about 20 vertebræ, and all except the first bear ribs. The second to the thirteenth are all about the same size. All are compressed to the thinness of paper, so that the details of their structure are obscure. Lower down the back the vertebræ slightly decrease in size. There is apparently only one sacral vertebra, which is always covered by the pelvic bones. There are about 21 vertebræ in the tail, gradually diminishing in size to a fourth of their original width.

The dorsal ribs from 2nd to 13th have a length equal to three-quarters of the width of a vertebra; posterior to this they become shortened. Ribs exist in the tail, and are about half as long as the vertebræ are wide.

The shoulder girdle includes seven bones, scapulæ, coracoids, clavicles and thoracic scute; and the pelvic girdle is formed by the iliac and ischiopubic bones. The hind-foot has the digits much longer than in the fore-foot, but the longest digit is the second, while in the fore-limb the third digit is longest. In the fore-limb the number of the phalanges is 2, 2, 3, 3, 2, and in the hind-limb it is 3, 4, 3, 2, 2.

The other species of *Branchiosaurus* which are described and figured are *B. umbrosus*, Frit., *B. Moravicus*, Frit., previously described as *Archegosaurus austriacus* of Makovsky, *B. ? venosus*, Frit., and *B. ? robustus*, Frit.

The next genus, *Sparodus*, Fritsch, is represented by two species: *S. validus*, Fr., and *S. crassidens*, Fr. It is nearly related to the American genus *Hylerpeton* and to *Brachiderpeton*. The large broad vomer carries numerous uneven large conical teeth. And the palatine bone has a single row of teeth, which increase in size posteriorly.

In *Sparodus validus* there are 17 teeth in the lower jaw; and there are 27 on each vomer, the largest rows being towards the palatine bone. The palatine bone carries 11 teeth. The skull is more wedge-shaped than in *Branchiosaurus*.

Of *Hylonomus* two species are recognized, but these are only known from small portions of jaws. *Hylonomus acuminatus* has the teeth marked with distant parallel ribs.

The last genus in the present part of the work is named *Dawsonia*. It is very nearly allied to *Hylonomus*, but the author is unable to see his way to uniting the genera, because Dr. Dawson figures elements of the skeleton which differ from the Bohemian specimens. The vomer (v) has a small group of minute teeth on its outer edge,

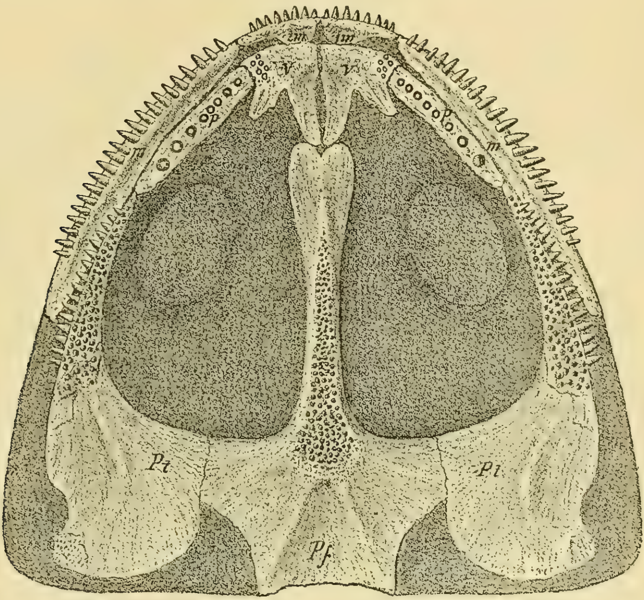


Fig. 5.—Restoration of the under-side of the skull of *Dawsonia polydens*, Fritsch. Twice the natural size.

and both the parasphenoid (Pf.) and pterygoid (Pt.) carry numerous small teeth. The palatine bone (p) has a single row of teeth which become larger posteriorly. The hindermost and largest tooth is grooved at the base. The external surface of the skull-bones is strongly sculptured. The thoracic scute has a long rhomboidal form, and is furrowed like the skull-bones. The teeth in the jaws are smooth and of uniform size. The premaxillary is broad, with about eight large teeth of equal size. The anterior process of the parasphenoid widens in front, and is slightly forked. This skull has never yet been found entire, but has been reconstructed from several fragments, and is believed to have been rather broader than long. The vomer (v) is forked behind, as though for the posterior nares. The pterygoid shows two kinds of dentition; on its outer edge is a single row of twenty-six large teeth of equal size, which are somewhat smaller than those of the maxillary bone. Internal to these on the anterior part of the pterygoid are from three to six irregular rows of short pointed teeth similar to those on the parasphenoid. In the under-jaw there are thirty teeth.

This instalment of Dr. Fritsch's work leads us to look forward to its subsequent progress with great interest. It is a monument of conscientious labour and admirable skill in deciphering remains in which the characters presented more than ordinary difficulty.

H. G. Seeley.

CORRESPONDENCE.

THE PURPLE BOULDER-CLAY AT HOLDERNESS.

Sir,—In the excellent account of English glacial deposits, given in the second edition of "The Great Ice Age," it is stated that "in Holderness the purple clay is quite unstratified." It is true, that in many places the "Purple Boulder-clay" is unstratified; but in many others it is distinctly stratified. The stratified and unstratified portions are, however, so mixed up together, and run so into one another, as to be quite inseparable. The deposit has also been much shoved about, the thrust having in some well-marked cases come from the N.N.E.

J. R. Dakyns.

Driffield, *Oct. 9th*, 1879.

ON THE CLASSIFICATION OF THE BRITISH PRE-CAMBRIAN ROCKS.

Sir,—Will you kindly call attention to the fact that by some mistake the word *not* has been left out after the word *did* in my paper, p. 434, line 19 from bottom of page. The sentence should read, "If these movements also did *not* take place, etc." As the absence of this one little word does away with the proper meaning, I shall feel obliged if you will kindly notice it in the next Number of the Geol. Mag.

Hy. Hicks.

Hendon, N.W., *Oct.* 3, 1879.

SURFACE GEOLOGY OF THE MISSISSIPPI VALLEY.

Mr. W. J. Mc Gee writes from Farley, Iowa, September 18, 1879, in reference to his communication, which appeared in the Geol. Magazine for August, pp. 353–362, and September, pp. 412–421:—"Thanks for your care in revising proofs of my paper in the Geol. Mag. A very few errors have crept in, however, which I will note.

W. J. Mc Gee."

Page 358 (August No.),	*line* 30,	*for*	"mentioned"	*read*	"weathered."
,, 359	,,	,, 26,	,,	"mass"	,,	"moss."
,, 361	,,	,, 33,	,,	"Level"	,,	"Lead."
,, 414 (Sept. No.),		,, 11,	,,	"basalt"	,,	"basal."
,, 418	,,	in footnote,	,,	"p. 168"	,,	"p. 105."

COLUMNAR SANDSTONE IN SAXON SWITZERLAND.

We are requested by Mr. Walter Keeping to make the following corrections in his article which escaped notice—namely, at p. 438, line 2 from foot, for 'binding' read 'bending.' and on p. 441, line 8 from top, for 'Yorkshire,' read 'Derbyshire.'—Edit. Geol. Mag.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. VI.

No. XII.—DECEMBER, 1879.

ORIGINAL ARTICLES.

I.—The Parallel Roads of Glen Roy.

By J. R. Dakyns, M.A.;
of H.M. Geological Survey of England.

LAST summer I paid a visit to the Parallel Roads of Glen Roy, and saw certain features which must, I think, have hitherto escaped notice. It has been asserted that the roads consist of, or are cut out of, mere superficial detritus; and that they never appear where the solid rock appears; and much discussion has arisen as to the mode of formation of the roads on this supposition, viz. that they consist of detritus merely.

In order to get a section of the roads, I examined several water-courses descending the side of Leàna Mhòr, west of the River Roy. These water-courses were cut to the depth of about ten feet in the ordinary superficial detritus of the mountain side; and where they crossed the roads, the material exposed on their sides was precisely the same as that along the rest of their course. This did not surprise me, as I had recently read in the Geological Magazine for July (p. 321), in a notice of a paper by Professor Prestwich, "On the Origin of the Parallel Roads of Lochaber," that "the Parallel Roads are terraces composed of perfectly angular fragments of the local rocks." However, as these water-courses nowhere reached the solid rock, I was not satisfied. I accordingly went next day to the east side of the River Roy, where the roads are very well marked indeed, and are crossed by two or three comparatively large gills. These gills descend along the west face of east Leàna Mhòr; for there are two hills of this name given on the One-inch Ordnance Map, one on the west, and the other on the east side of the River Roy.

I walked along the topmost road northward; and the first gill I came to showed me at once that the road was cut out of the solid rock. Both above and below the road the solid rock came practically to the surface, being covered with a mere film, about a foot thick, of its own detritus: the surface along the road itself was, however, hidden by a small fan of detritus shot on to the road from the gill above. The section of the second or middle road was obscure along this gill. I walked on along the highest road till I came to a big gill cut deeply into the native rock, and bifurcating a little below the 1250 contour line. The highest road crosses this pair of gills above the point of bifurcation, and was so utterly destroyed as to be quite obscure; but the second road ran right up to the edge of the deep gill, which it meets just below the junction of the two branch gills, and started at once again on the opposite side; no talus concealed the road; it is cut out of the solid rock. A subordinate road which occurs a little further north between the two ordinary top roads was also seen to coincide with and, in fact, to be a rock feature.

I was satisfied: I went no further: I had had two clear sections of the two best-marked roads, one of each: the roads are, at all events in some cases, cut out of the solid rock. It is reasonable to conclude that where they appear to be confined to superficial detritus, it is because the rock shelf is hidden by said detritus, which has, in fact, accumulated along the road just because it is a shelf. It is noteworthy that whereas the roads on the east side of Roy, where being free of detritus they are seen to form rock shelves, are wide enough to allow two carts to pass each other. On the west side where encumbered with debris they are no broader than a good sized foot-path.

The roads, though sensibly parallel and horizontal, are not absolutely so; for, according to the measurements of the Ordnance Surveyors, the first road in Glen Roy varies in elevation from 1144 to 1155 feet above the sea, the second from 1062 to 1077, and the third from 850 to 862. Such variation in height would necessarily be caused by the unequal accumulation of debris on the original shelves.

It is right to say that there is an error in the mapping of the roads on the One-inch Ordnance Map, Sheet 63: on the map the topmost road is represented as crossing the big two-grained gill just below the bifurcation; it really is considerably higher up, while it is the second or middle road which crosses the gill at the fork.

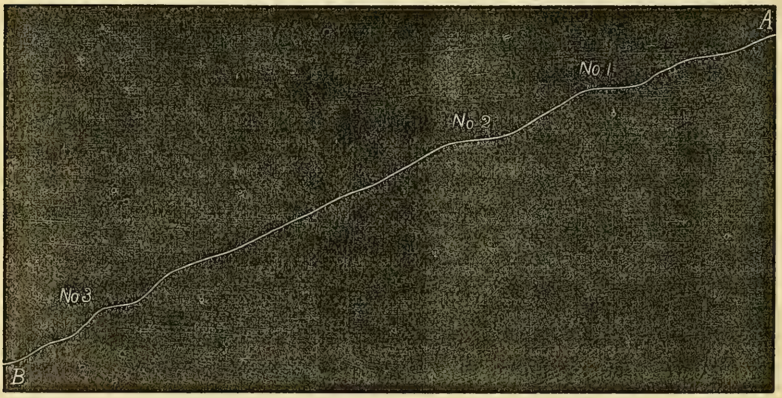


Diagram showing the profile of the mountain side with the three roads, the two highest, Nos. 1 and 2, well marked, and the lowest, No. 3, not so well marked, as seen by an observer looking up Glen Roy.

I have not seen the places where, as Mr. Darwin[1] observes, the shelves entirely disappear on crossing the part of the mountains in which the base-rock is exposed; but I would ask whether the rock

[1] Quoted by Sir John Lubbock, Quart. Journ. Geol. Soc. vol. xxiv. p. 84.

may not be more than usually tough in these places. Generally the rock seemed to me to be of a character easily disintegrated.

How then were the roads formed? Obviously by the planing action of waves acting on the rock and cutting the shore-line back. Subsequently, on the lowering of the water-line, the detritus of the mountain side falling, and being washed down hill by rain, etc., lodged on the platform of the shelves, and there accumulating gradually formed a pile of loose material sloping towards the valley, and slowly obliterating the true roads.

I add a sketch of the profile of the mountain side, as seen from the big gill looking up the valley. It will be seen that my profile is quite similar to the diagram given from Macculloch by Sir John Lubbock in the Q.J.G.S. for 1868, vol. xxiv., with this remarkable difference: in my sketch the two highest roads are represented as comparatively near to one another, while the lowest is much lower down; this is the case in nature; the average heights of the roads above sea-level being, according to the Ordnance Surveyors, 1148, 1067, and 855 feet; but in Sir John Lubbock's diagram, after Macculloch, the two lowest roads are represented as close together, and the third much higher up: the diagram has evidently been drawn or printed upside down; for turn the book topsyturvy and the diagram is right.

As to the nine points then, on which, according to Sir John Lubbock, we have a substantial agreement, the whole question of the true nature of the roads turns upon the second and third: these I would controvert thus: the horizontal roads are shelves cut out of the solid rock; and these shelves only appear when the solid rock itself appears, being in other cases entirely hidden by the debris of the mountain side, which has fallen and accumulated upon the shelves.

It is further to be noted that the disintegration of the rock forming the shelves would in course of time disguise the fact that the roads consisted of rock shelves, and cause them to appear as mere heaps of detritus.

II.—Description of a New Species of Fossil Fish Spine, *Ctenacanthus minor*, from the Lower Coal-measures of Yorkshire.

By James W. Davis, F.L.S., F.G.S., etc.;

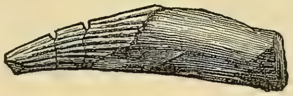
Hon. Secretary of the Yorkshire Geological and Polytechnic Society.

A SHORT time ago, whilst examining and appending the names to a number of specimens of fossil fish in the collection of the Bradford Philosophical Society, which are being arranged and exhibited in the new Corporate Museum in that town, I came across the spine which is the subject of this notice. It is from the Black-bed Coal at Dudley Hill, near Bradford. It was associated with a number of fish remains, amongst others :—

Ctenacanthus hybodoides, Egerton.
Gyracanthus formosus, Agass.
Pleuracanthus lævissimus, Agass.
Diplodus gibbosus, Agass.
Ctenoptychius, sp.
Petalodus Hastingsiæ, Agass.
Acanthodes, sp. ?
Megalichthys Hibberti, Agass.
Cœlacanthus lepturus, Agass.
Rhizodus Hibberti, Agass.

Several specimens of *Labyrinthodonts,* in excellent preservation, have been found along with the remains of the fishes. One of them, a new genus of large size, was described and named by Professor Huxley *Pholiderpeton scutigerum.*

The Black-bed Coal is in the Lower Coal-measures about 120 feet higher in the series than Elland Flag-rock. Immediately above the Coal there is a bed of shale containing a considerable quantity of Clay-ironstone in nodules, which is worked by the Low Moor Iron Company along with the Coal. The fossil fish and *Labyrinthodonts* are from this shale immediately above the Coal.



Ctenacanthus minor, Davis, sp. nov. (Natural size.)

Ctenacanthus minor, mihi. Spine: length, 1·4 inches; greatest breadth, ·3 of an inch. The base is imperfect, and the tip of the spine is also wanting. It is slightly curved, is very strong, and has been very deeply implanted in the flesh; the basal portion constitutes more than half the entire length, and if the specimen had been perfect would have taken up quite two-thirds; probably a larger proportion than exists in any other species of *Ctenacanthus.* The lateral faces are compressed anteriorly; posteriorly they expand and give to a section of the spine a triangular form. Along the back of the spine there is a deep groove, no posterior denticles can be seen. The line dividing the exposed part of the spine from the base forms an angle to the length of the spine of about 45°. The anterior portion is produced so as to form a median keel, whilst on each side there are six or seven well-defined ridges or costæ separated by deep intercostal spaces. The ridges run parallel to the posterior margin for the most part, whilst those near the anterior portion run out towards the point without impinging on the median keel.

This spine does not appear to be in close relationship with any of Ctenacanths hitherto described. Its short wedge-shaped form in the part exposed, and the extremely large and strong base, serve to distinguish it from all other species of the genus. I suggest the specific name *minor* as signifying its relatively small size.

III.—On the Occurrence of the Keuper Basement Beds in the Neighbourhood of Nottingham.

By E. Wilson, F.G.S., and J. Shipman.

Hitherto, exposures of the junction of the Bunter formation with the Keuper, in the Nottingham district, have shown the brown sandstones and red marls of the "Waterstones," with a band of dolomitic conglomerate at the base, resting directly on an eroded surface of the Bunter Pebble Beds.[1] Recently, however, between

[1] J. Shipman, "Conglomerate at the Base of the Lower Keuper," Geol. Mag. 1877, p. 497.

these formations there have been observed to intervene certain deposits that agree both in mineral composition and in physical characters with the white sandstones and conglomerates, known as the "Basement Beds,"[1] that form so important a feature in the Keuper of the West Midlands.

The Hunger Hills.—These "Basement Beds" were exposed to view during the progress of some excavations on the Hunger Hill Road, Nottingham, and a good section showing their junction with the Bunter Pebble Beds was supplied by a cutting for a culvert in Beverley Street. These rocks here consist of soft coarse and "sharp" grained white micaceous sandstone. Owing to inequalities in the surface of the Bunter, they vary rapidly in thickness from a few inches only to as much as six feet. Throughout the sandstone are scattered quartzite pebbles like those of the "Pebble Beds," but it was in the cavities in the old surface of the Bunter that the pebbles were mostly met with. Two deep furrows in the Bunter surface trended from west to east, shallowing out on the west. About two hundred feet further east, the white sandstones were again found resting on a ridged and undulating surface of the "Pebble Beds." The "Basement Beds" were not at this spot proved over a greater space than about $250' \times 300'$, being cut off and overlapped by the Keuper dolomitic conglomerate on all sides, except the north-east, where they were lost to view beneath the Lower Keuper Sandstone of the Hunger Hills. They appear to occupy a shallow cavity eroded out of a plane of Bunter sloping to the east at about one in fifty. The upper surface of the white sandstone itself showed distinct signs of erosion, being worn into irregular hummocks and cavities, filled in with the rusty-coloured sand and pebbles of the Keuper conglomerate.

Colwick.—The "Basement Beds" were also exposed in the tunnel for the Leen Valley Outfall Sewer, at Rough Hill Wood, near Nottingham.[2] These Beds consist of at least twenty feet of massive light-grey micaceous and felspathic sandstone, grit and conglomerate, with lenticular seams of red marl. False-bedding is prevalent in the sandstones, the planes sloping east at from 5° to 25°. The pebbles are nearly all quartzites or quartz, and agree with those of the Bunter Pebble Beds, except that many of them have chipped corners or angular faces as if fractured during transport or the process of deposition. In the tunnel heading near the top of the series is a bed of marl, that for a space of about a hundred feet maintains a thickness of from two to four feet, and then becomes split up into wedges that dovetail in a peculiar manner with the beds of sandstone and conglomerate that it locally displaces. These beds show signs

[1] Hull, "Triassic and Permian Rocks of the Midlands," pp. 66, *et seq.*

[2] We are indebted to C. F. Gripper, Esq., contractor for the works, and to M. O. Tarbotton, Esq., F.G.S., Engineer to the Nottingham Corporation, for the lower portion of the third section, which was arrived at by means of a shaft sunk for the purpose at Rough Hill Wood; but owing to the water-level of the Trent valley being reached, the sinking had to be abandoned without proving the Bunter.

In consequence of the great length of two of the sections referred to, their publication with the present paper has been abandoned by its authors.

of contemporaneous erosion, the sands having been apparently cut through by channels and replaced by other sands or by marls, while the marls have been broken up and their débris, in the shape of flakes, and lumps, scattered plentifully through the surrounding sediments. Notwithstanding their intimate association with the coarser deposits, the marls keep remarkably fine and pure. These rocks are succeeded by the regularly bedded sandstones and marls of the Lower Keuper. The line of junction, which is sharply defined, is pretty level, but the "Basement Beds" appear to have been truncated by denudation prior to the deposition of the Waterstones.

Other Localities.—The "Basement Beds" of the Lower Keuper are very variable in thickness, and, except in their areas of typical development, very irregular in distribution. Prof. Hull long since showed that the sediments which compose the Keuper rocks of England probably came from the west or north-west; for he demonstrated that the Triassic rocks, along with other Secondary formations, attenuate in a south-easterly direction.[1] It was therefore to be expected that this lowest member of the Keuper would be found to thin away going east, and such is actually the case. On the west, in Delamere Forest, and the Peckforton Hills, Cheshire, the Basement Beds proper are from 50 to 150 feet thick, but, with the overlying red and white freestones, attain a thickness of 250 feet or more.[2] At Alton, midway to Nottingham, these rocks are not more than sixty feet, while still further east, at Nottingham, they probably do not exceed twenty feet in thickness. East of the valley of the Dove, these rocks rapidly attenuate, and are soon lost beneath newer members of the Keuper, which then repose directly on the Bunter Pebble Beds. Nor do they appear to be present between the Derwent and the Erewash. Crossing that stream, however, we again meet with them—at Bramcote, Notts—as a few feet of calcareous sandstone cropping out from beneath the "Waterstones." They are found at Highfields, two miles nearer Nottingham, resting on an eroded surface of Bunter Pebble Beds. Here they consist of about seven feet of thick-bedded cemented quartzose grit, with bands of compact conglomerate. They are also exposed in a small boss of rock, at their outcrop near Rough Hill Wood—the most easterly point at which they are to be seen in this country. We have not attempted to trace these rocks further south than Burton-on-Trent, near to which they are to be seen at Bladon Hill, in the Trent escarpment, as white quartzose false-bedded grits, with thin grey micaceous sandstones. Red grit and pebbly sandstone, apparently belonging to this series, are exposed near Ticknall, South Derbyshire, between Heath Wood and Seven-Spouts. These beds are, however, absent further east at Melbourne and at Castle Donington.

Conclusions.—To arrive at satisfactory conclusions as to the physical conditions under which the Basement Beds of the Lower Keuper were formed, is no easy matter. That these rocks are all of

[1] Hull, "On the South-easterly Attenuation of the Secondary Rocks of England," Quart. Journ. Geol. Soc. vol. xvi. p. 66.

[2] Hull, "Triassic and Permian Rocks of the Midland Counties."

the same age, and have all had a common origin, their remarkable uniformity in mineral character and in physical structure, in districts so widely separated as Cheshire and Nottingham, satisfactorily demonstrates. The easterly attenuation of these beds indicates that their source lay in an opposite direction, whilst the nature of their materials—the angular grains of quartz, the abundance of mica, and the abundance and often undecomposed state of the felspar in the sandstones, point to their derivation from the breaking up of crystalline rocks such as granite and highly altered schists. These sediments appear to have been drifted by westerly currents along a strait or series of shallow channels, that in early Keuper times stretched across the Midlands, and which, owing to preponderating subsidence in that direction, covered a large area in the west, but became narrower towards the east. This channel was shut in by the southern flanks of the Pennine Hills on the north, and by the Carboniferous rocks that flank the Leicestershire Coal-field and Charnwood Forest on the south. For, north of a line drawn through Alton, Derby, and Nottingham, the Basement Beds rapidly thin out, while east of Burton-on-Trent they likewise speedily attenuate, and eventually disappear; nor have we any reason for supposing that they were ever deposited any distance north or south of where we now find them.

IV.—Further Notes on a Collection of Fossil Shells, etc., from Sumatra (obtained by M. Verbeek, Director of the Geological Survey of the West Coast, Sumatra). Part IV.[1]

By Henry Woodward, LL.D., F.R.S., etc.;
of the British Museum.

(PLATES XIV. and XV.)

50. *Triton*, sp. (cast of). Pl. XIV. Fig. 1.

This cast indicates a fusiform turrited shell adorned by discontinuous varices; the spire is wanting; it also shows that the shell was transversely ribbed and corrugated; the outer lip was strongly plicato-dentate internally; the aperture rather small; canal moderately long.

From the general aspect of this cast, I think it probably may be referred to the *Triton corrugatum*, Lamk., so widely distributed in our European Miocene deposits; and found living in Vigo Bay (S. P. Woodward) and in the Mediterranean.

Formation:—In light-coloured (Miocene) Tertiary clay-marl.

Locality:—Government of the West Coast of Sumatra.

51. *Pleurotoma terebra*, Basterot, 1825. Pl. XIV. Fig. 2*a*, *b*.

Pleurotoma terebra, Basterot, 1825, Mém. géologique sur les Env. de Bordeaux. Paris, 1825, pl. 3. fig. 20.

———— *multinoda*, Des Moulins, 1843, Revision des Pleurotomes; Actes Soc. Linn. de Bordeaux, tome xii. p. 167.

———— *Dufourii*, Des Moulins, op. cit. p. 180.

———— (*Clavatula*) *sinensis*, Hinds, 1843, Proc. Zool. Soc. p. 38, pl. v. fig. 10, and 1844, Zool. Voyage of H.M.S. Sulphur, vol. ii. p. 17, pl. v. fig. 11.

[1] Continued from the November Number, p. 500.

Shell fusiform, costellated, transversely striated, whorls 8-9 in number, somewhat angular, tabulated above, smooth; costæ thick, prominent at the angles, truncated above; suture marginated; aperture scarcely equal to half the length; canal straight; columella smooth; lip thickened, expanded, striated within, sinus deep, rounded.

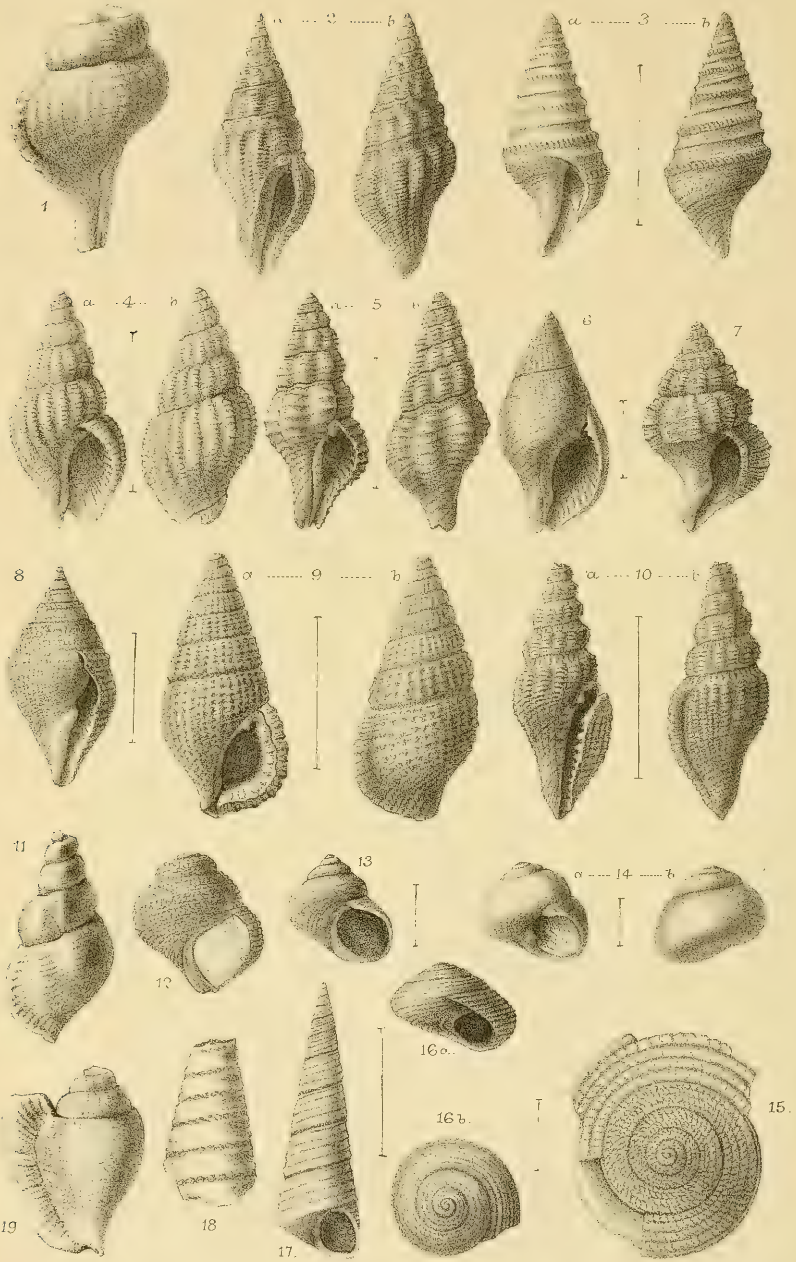
After instituting a careful comparison between this Sumatran fossil and a series of very similar forms from the Miocene faluns of Touraine, Dax, and Bordeaux, obtained by M. Deshayes for the British Museum, and figured and described by MM. Basterot, and Des Moulins, I have arrived at the conclusion that this *Pleurotoma*, Pl. XIV. Fig. 2*a*, *b*, is identical with the *Pleurotoma terebra*, Bast., and that *Pl. multinoda*, Des Moulins, and *Pl. Dufourii*, Des Moul., must also be considered as synonymous with it, and with the Sumatran species; the variations which they present being only individual, and too trivial to be treated as of specific value.

I have further compared this Sumatran fossil with the *Pl.* (*Clavatula*) *sinensis* of Hinds,—a recent shell found living at New Guinea, the Straits of Macassar, Celebes, in the China Seas, and at Malacca;—and in doing this I have had the benefit of the opinion of my colleague Mr. Edgar A. Smith, of the Zoological Department. The chief differences appear to be in the form and proportion of the last whorl to the entire length of the shell, the last whorl being smaller and shorter in the recent shell, than in the fossil. In the Sumatran fossil it is less contracted and attenuated towards the base, and occupies nearly half the entire length, but in *Pl. sinensis* it is much shorter in proportion. In the latter, the upper part of the volutions is more concave beneath the wavy keel, or ridge, which borders their margin, and the costæ or plicæ are more prominent and slightly more angular. The spiral or transverse sculpture offers but little difference in the two species.

In all the larger specimens of this form from Bordeaux (especially in *Pl. terebra*, and *Pl. multinoda*) the aperture is always considerably less than half the entire length of the shell; but in the smaller French specimens the proportions are nearly the same as that of the smaller Sumatran one. The spire of the smaller specimens is also more acute.

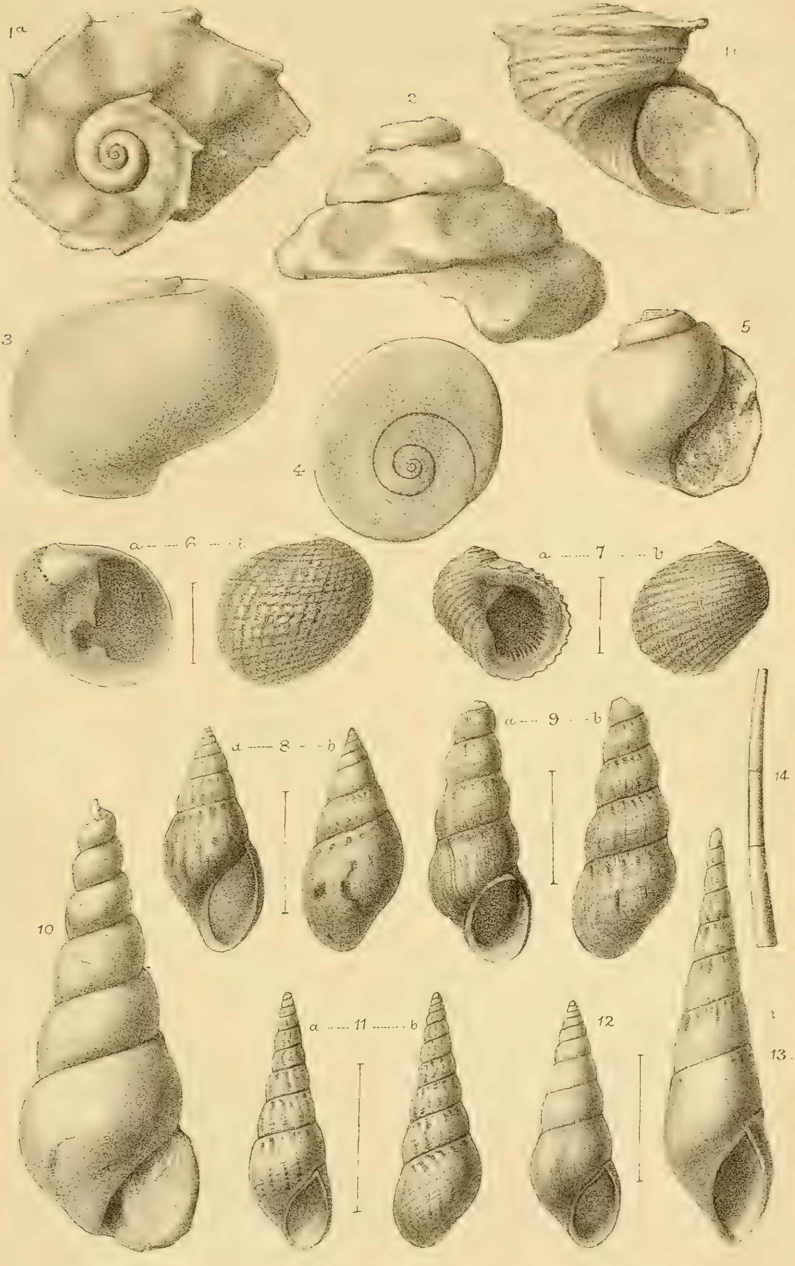
The following are the relative dimensions of the species of *Pleurotomæ* referred to:—

	Large Specimen.			*Small Specimen.*		
Species of *Pleurotoma* proposed to be placed together.	Length of Aperture.	Length of Shell.	Breadth of Shell.	Length of Aperture.	Length of Shell.	Breadth of Shell.
Pleurotoma terebra, Bast. Sumatra ...	12	30	10	8	16	6
——— ——— ,, Bordeaux...	10	26	8	7	19	7
——— *multinoda*, Lamk. Saubrigues. Dax.	11	30	10	9	17	7
——— *Dufouri*, Des Moul. Dax.	—	—	—	7	17	6
——— *sinensis*, Hinds (recent) ...	9	22	7	7	17	6



C. L. Griesbach del. et lith. West, Newman & Co. imp.

Sumatran Tertiary Shells.



C.L. Griesbach del. et lith.

West, Newman & C° imp.

Sumatran Tertiary Shells.

Although the divergence pointed out between our Sumatran shell and the recent *Pleurotoma sinensis* of Hinds may be deemed sufficient in the eyes of recent students of Malacology to separate the two specifically, yet we venture to think it probable that we have in *Pl. sinensis*, Hinds, only the modern representative of the Sumatran fossil, and also of the *Pl. terebra*, Bast., with its associated forms from the Miocene of France.

Should this view find favour, then four species, hitherto separated, will in the future be enrolled under one name, as *Pl. terebra*, Bast., or be treated as varieties only, a method particularly convenient in dealing with genera of Mollusca, which are extremely rich in species and varieties, like *Pleurotoma*.

Formation:—In bluish-grey Tertiary Marl-clay.

Locality:—Government of the West Coast of Sumatra.

52. *Pleurotoma concinna*, Dunker, 1856. Pl. XIV. Fig. 3*a*, *b*. Proc. Zool. Soc. Lond. 1856, p. 356.

The following is a translation of Prof. Wm. Dunker's description of *Pleurotoma concinna*:—

Shell acutely-turrited, subfusiform, solid; colour light-reddish brown; mouth and canal roseate, encircled with elevated lines and ridges; whorls about 10, slightly convex; suture indistinctly divided; last whorl scarcely equal to the height of the spire; canal sub-oblique; fissure in outer lip deep.

Dimensions of recent shell: length 27 mm.; greatest breadth 9 mm.; length of aperture 12 mm.

There can be no doubt of the identity of our fossil, Pl. XIV. Fig. 3, with the living *Pleurotoma concinna*, of Dunker, specimens of which are preserved in the British Museum, said to have been obtained from Sibonga in the Philippine Islands, and from New Ireland. It differs from that species, at first sight, in being shorter and of less slender build, with a shorter basal canal. (The length of the canal, however, should in all probability have been greater than the artist has represented in our Figure, as the extremity of the canal is certainly abraded.)

The whorls in the fossil are more deeply excavated than in the recent specimens, both above and below the central carina, the nodules of which are more clearly defined in the fossil. The other spiral liræ and oblique sculpture also offer certain differences. The suture is less deep in the fossil than in the recent shell from New Ireland, but equals that of the type specimen. In the fossil form the surface reticulations are more strongly marked than in the recent species, approaching in this respect more nearly to the *Pl. cataphracta* of Brocchi from Dax. It agrees also with *Pl. Hantoniensis*, Edw., in having the line of tubercles upon the central carina divided into two; but the striæ in *Pl. Hantoniensis* are somewhat coarser and less markedly reticulated. This shell might also be compared with *Pleurotoma turbida*, Solander, and *Pl. granata*, Edw. Near the apex the four earliest whorls of the young shell in the fossil are seen to be roundly inflated and simply ribbed longitudinally. The apex in *Pl. cataphracta*, and less markedly so in the recent *Pl. concinna*, exhibits the same embryonal character.

Dimensions of fossil:—Length of smaller shell 18 mm.; of larger specimen (anterior canal partly broken off) estimated at 21 mm.; breadth smaller shell 7½ mm.; larger specimen 8½ mm.

Formation:—In bluish-grey Tertiary Marl-clay.

Locality:—Government of the West Coast of Sumatra.

53. *Phos Borneensis*, Sowerby, 1866. Pl. XIV. Fig. 4*a*, *b*.

Shell subfusiform, turrited, encircled with distant spiral liræ and prominent nodular rounded ribs, finely striated between the ribs; costæ narrow, somewhat distant (the regularity of the ornamentation is occasionally broken by a few discontinuous varices, more prominent than the equidistant costæ); thickened on the varix behind the aperture; aperture narrow below; canal subrostrate; lip corrugated within; whorls 7–8 in number.

Dimensions:—Height of shell 21 mm.; breadth of shell 10 mm.

This shell appears not to be separable specifically from the living Bornean form. The whorls are perhaps a trifle less shouldered at the upper part, the spiral liræ are more numerous, and the minute or subordinate sculpture is also of a finer character.

The thread-like lirations within the aperture are more numerous, and the oblique simple keel which winds round the extremity of the body-whorl is more distinct. These are but trifling differences, and hardly sufficient to entitle the Sumatran fossil to separate specific rank. The general facies of this fossil and normal examples of the living shell is remarkably similar, the proportion of the whorls being identical.

Formation:—In bluish-grey Tertiary Marl-clay.

Locality:—Government of the West Coast of Sumatra.

54. *Phos subplicatus*, H. Woodw. (not figured).

Shell solid, turrited, liræ scabrose, costæ nodular, spirally cinctured; spire short, 5-6 whorls, whorls somewhat rounded; costæ rounded, tolerably close, more numerous near the aperture.

Dimensions:—Height of shell 12 mm.; greatest breadth 7 mm.

The shell of this species is much shorter in the spire, and increases in size more rapidly than that of the preceding one. It closely resembles the *Phos plicatus*, A. Adams (Proc. Zool. Soc. 1859).

It differs from the recent *Phos plicatus* in the less angularity of the whorls and the more rounded character of the ribs; they are also less close-set than in the recent form.

We have ventured to consider this as distinct.

Formation and Locality:—Found with the preceding species.

55. *Turbinella subcostata*, H. Woodw. Pl. XIV. Fig. 5, *a*, *b*.

Shell fusiform, subturrited, thick; spire with the sutures somewhat squamose, whorls about 7 in number, with prominent rounded costæ transversely plicated; plicæ about three in number (more numerous upon the body-whorl); plications acute; aperture small, ovate, and canaliculate, posteriorly notched, sulcated within; columella thickened and subtransversely triplicated; canal moderately long.

Dimensions:—Height of shell $17\frac{1}{2}$ millimètres; greatest breadth 8 mm.; length of aperture 8 mm.

This shell approaches nearly to the *Turbinella subcraticulata* of D'Orbigny, figured by Dr. Hörnes (in Die Fossilen Mollusken des Tertiaer-Beckens von Wien, fol. 1856, Band I. p. 302, taf. 33, figs. 10 *a, b*),—a species also found at St. Paul, near Dax. The Sumatran shell has, however, a less acute spire than that from the Vienna Basin; the canal is straighter, the aperture smaller, and the body-whorl less in proportion. The spiral lirations are also fewer.

Formation and Locality:—The same as the preceding species.

56. *Pisania subdiscolor*, H. Woodw. Pl. XIV. Fig. 6.

Shell elongated, fusiform, apex sub-acute, whorls six in number, spire delicately cancellated, body-whorl finely striated; aperture somewhat elliptical, one-half the entire length of shell, inner border of outer lip canaliculate; denticulated near the posterior extremity, anterior canal slightly produced, and notched; columella smooth, slightly thickened, with a small denticulation near the posterior extremity of the aperture.

Dimensions:—Height 10 mm.; breadth 5 mm.

Most of the species belonging to this genus are represented by small shells which have very generally been confounded with *Buccinum, Murex, Ricinula,* and *Nassa.*

These shells have numerous indistinct varices, or are nearly smooth and spirally striated; the canal short, inner lip wrinkled, outer lip crenated.

Our Sumatran shell might easily be mistaken for a dwarfed form of *Pisania* (*Buccinum*) *discolor* (Quoy and Gaimard, Voyage de l'Astrolabe, 1832, Zoologie, tome ii. p. 422, pl. 30, figs. 23–25), specimens of which in the British Museum are labelled as from the "China Seas." On close inspection, however, the whorls are seen to be more numerous, the apical ones being smaller and less mammillated in character. The last whorl is a trifle more constricted just below the middle, and the basal canal is a little longer. The style of sculpture and proportions of the whorls, however, are very similar.

It may also be compared with the *Pisania* (*Nassa*) *Andrei*, Bast. (1825), pl. iv. fig. 7, from the Miocene of Bordeaux.

Formation:—Grey Tertiary Marl-clay.

Locality:—Government of the West Coast of Sumatra.

57. *Ranella ? tritonoides*, H. Woodw. Pl. XIV. Fig. 7.

Shell subturrited, ventricose (lateral varices scarcely so continuous as in most of the species referred to this genus, and for that reason doubtfully placed under it); transversely lirate, liræ numerous, three being more prominent than the rest, and becoming more distinctly marked as they pass over the costæ; longitudinally costated, costæ prominent, body-whorl somewhat ventricose, aperture ovate, dilated anteriorly, obliquely canaliculate, columella obscurely biplicate.

Neither of the two specimens of this shell have the mouth perfect.

Formation and Locality:—With the preceding.

58. *Borsonia granifera*, H. Woodw. Pl. XIV. Fig. 8.

Shell fusiform or biconical; spire conical, acute, sutures scarcely marked, body-whorl equal in length to the spire, aperture narrow, outer lip ridged, columella with one prominent fold, surface ornamented with numerous transverse ridges distinctly granulated, the two ridges near the suture being more prominent than the rest.

Dimensions:—Height 15 mm.; breadth 8 mm.

This shell may be compared with species of the genus *Conorbis* of Swainson, and particularly with *C. dormitor*, Solander, from the M. Eocene, of Barton, Hants, etc. (Edwards, Eocene Moll. part iii. 1856, p. 200, tab. xxiv. fig. 11 *a*, *b*, *c*, Pal. Soc. Mon.), from which it differs, however, in being more tumid and in the granulated nature of its ornamentation. The prominent fold on the columella is also wanting in that species.

Formation and Locality:—Found with the preceding species.

59. *Cerithium Verbeekii*, H. Woodw. Pl. XIV. Fig. 9 *a*, *b*.

Shell turrited, volutions nine to ten in number, flattened; suture distinct, each volution with about four rows of prominent transverse tubercles separated by distinct striæ; granulated on the body-whorl, tubercles arranged in regular rows; aperture sub-rotund, outer lip thickened, the inner margin very prominently crenated, inner lip slightly arcuate, posterior canal well marked, anterior short and oblique.

Dimensions:—Height 20 mm.; breadth 10 mm.

This shell may be compared with the *Cerithium Duboisii* of Hörnes, 1856 (Fossilen Mollusken des Wiener Beckens, p. 399, taf. 42, figs. 4 and 5). It differs, however, from this Austrian species, in being more robust in its spire, in the larger size of its body-whorl, in the aperture not being inflated, and lastly in possessing a thickened and prominently crenated outer lip.

I dedicate this species to Mynheer Verbeek, the Director of the Geological Survey of the Government of the West Coast of Sumatra, whose careful researches have resulted in so large an addition being made to our geological and palæontological knowledge of this distant region of the earth.

Formation and Locality:—Found with the preceding species.

60. *Pleurotoma* (*Glyphostoma*, Gabb) *Jonesiana*, H. Woodward. Pl. XIV. Fig. 10*a*, *b*.

Shell subfusiform, spire elongate; volutions somewhat convex, longitudinally costated, costæ prominent, nearly straight and ornamented or crossed by from three to five transverse ridges or liræ; suture distinct and depressed, ornamented or marked with curved ridges, more numerous than the costæ; aperture narrow, elongate, outer lip thickened, and strongly denticulate, inner lip distinctly and closely plicated; canal slightly produced and recurved; ornamentation on body-whorl somewhat moniliform in consequence of the greater prominence of the transverse striæ as compared with the costæ.

Dimensions:—Height 22 mm.; breadth 10 mm.

This form presents a general resemblance to the *Pleurotoma strom-*

billus of Dujardin (Mém. sur les Couches du Sol en Touraine, 1835, Mém. Soc. Géol. France, p. 290, pl. xx. fig. 15), but in that species the volutions are more tabulate, and the aperture is wider and shorter, and less distinctly denticulated.

It may also be compared with the illustrations of the same species given by Hörnes, p. 79, t. 40, figs. 1 and 2 (1856, Fossilen Mollusken des Wiener Beckens) from the Vienna Basin.

I dedicate this species to my esteemed friend Prof. T. Rupert Jones, F.R.S., F.G.S., to whose kindness I am indebted for the opportunity of examining and describing this very interesting collection of Sumatran fossils.

Formation:—In bluish Tertiary Clay-marl.

Locality:—Government of the West Coast of Sumatra.

61. *Ranella*? sp. (cast). Pl. XIV. Fig. 11.

Judging from the presence of continuous varices on this cast, we should attribute it to a species of *Ranella*. It represents an elongated turrited shell, with convex, rapidly-increasing, transversely-costated volutions; outer lip strongly denticulated within; varices continuous.

Dimensions:—Height 28 mm.; breadth 14 mm.

Formation:—In white Tertiary Clay-marl.

Locality:—Government of the West Coast of Sumatra.

62. *Turbo Smithii*, H. Woodw. Pl. XIV. Fig. 12.

Shell somewhat pyramidal, imperforate, volutions convex, whorls about five in number, banded with numerous parallel spiral liræ, the larger ones prominently tuberculated or moniliform, the intervening ones, especially on the body-whorl, being less distinctly marked, the ornamentation becoming more squamose on the body-whorl; aperture plain, ovate.

Dimensions:—Height 17 mm.; breadth 15 mm.

I venture to name this species after my colleague Mr. Edgar A. Smith, F.Z.S., whose kind assistance has been at all times most willingly afforded me in my researches.

Formation:—In white Tertiary Clay-marl.

Locality:—Government of the West Coast of Sumatra.

63. *Turbo Sumatrensis*, H. Woodw. Pl. XIV. Fig. 13.

Shell moderately thick, turbinate, spire rather elevated, whorls tumid, slightly angular above, with numerous minute ridges crossed by very oblique longitudinal striæ, giving the shell a faintly reticulate appearance; aperture circular; inner lip somewhat callous.

Dimensions:—Height of shell 8 mm.; breadth 8 mm.

This shell may be compared with the *Turbo squamulosus*, Lamk., (see Deshayes, 1837, Descrip. des Coquilles Foss. des Env. de Paris, Atlas, pl. 32, figs. 4 and 5), but the French specimen is more strongly squamose and much larger in size.

Formation:—From Tertiary deposit? (no matrix visible).

Locality:—Government of West Coast of Sumatra.

64. *Monodonta submamilla*, H. Woodw. Pl. XIV. Fig. 14, *a*, *b*.

Shell subturbinate, smooth, rather thick, volutions five in number, rounded; aperture subovate, oblique, produced, inner lip toothed, callous, nonumbilicate, very faintly striated; columella solid, base of shell somewhat flattened.

Dimensions :—Height 7 mm.; breadth 7 mm.

This shell presents some resemblance to the *Monodonta mamilla* of Andrzejowski (figured by Hörnes in Fossilen Mollusken des Tertiär Beckens von Wien, p. 438, t. 44, fig. 8), but the whorls are not quite so inflated in appearance as in our Sumatran form.

Formation and Locality :—With the preceding species.

65. *Solarium Javanum?* Martin. Pl. XIV. Fig. 15.

Shell orbicular, depressed; umbilicus wide and deep; the upper surface of each whorl encircled by about four sets of spiral moniliform liræ, margin of umbilicus strongly corrugated. So far as the very imperfect state of this specimen permits us to form a comparison, we have little doubt in referring it to the *Solarium Javanum* of Martin (Die Tertiärschichten auf Java, p. 74, tab. xiii. figs. 2, 2*a*), but the Sumatran shell is much smaller.

Formation :—In bluish Tertiary Clay-marl.

Locality :—Government of the West Coast of Sumatra.

66. *Turbo Martinianus,* H. Woodw. Pl. XIV. Fig. 16*a, b.*

Shell orbicular, depressed; whorls 4 to 5 in number, convex, transversely finely sulcated, sulci regular, very faintly and obliquely striated between the sulcations; base of last whorl somewhat flattened, umbilicus closed in the adult; in specimens in which the callous has been removed by decortication, the shell is seen to be deeply and widely umbilicated, the sides of the umbilicus being striated within; aperture of shell rounded.

This shell agrees closely in form and general ornamentation with the *Turbo planorbularis* of Deshayes, from the Calcaire Grossier Houdan (see Descrip. des Coq. Foss. des Env. de Paris, 1824, tome ii. p. 258, pl. 33, figs. 19-22), but the French specimen is much smaller and the umbilicus is not closed.

The French specimen is only 3 mm. in height and six in diameter. The Sumatran shell is 11 mm. in height, and 15 mm. in diameter.

I have named this specimen after Dr. K. Martin, whose fine folio memoir, with its excellent plates, Die Tertiärschichten auf Java (1879), now in course of publication, promises, when completed,[1] to be of great value to palæontologists.

Formation :—In whitish Tertiary Clay-marl.

Locality :—Government of the West Coast of Sumatra.

67. *Turritella,* sp. Pl. XIV. Fig. 17.

All that is preserved to us of this specimen is the upper part of the spire of a *Turritella,* very near to the group of *Turritella imbricataria,* in which the suture is very indistinctly marked (much less so than the artist has represented in the Plate), and the volutions are ornamented with a series of transverse ridges alternately larger and smaller, the latter being more numerous than the former.

Formation :—In bluish-grey Tertiary Clay-marl.

Locality :—Government of the West Coast of Sumatra.

[1] Part I. containing the *Univalves,* with fourteen plates, has already appeared (Leiden, E. J. Brill, 1879, pp. 94, folio).

68. *Cerithium*, sp. Pl. XIV. Fig. 18.

This is a portion of the spire only of a very much waterworn shell, belonging to the group of *Cerithium mutabile*, showing the suture bordered on each side by a line of tubercles both above and below, with one or more intermediate striæ. It may be compared with the *Cerithium Hellii* of D'Arch. (Foss. Numm. de l'Inde, t. 29, fig. 1).

Formation and Locality:—Found with the above.

69. *Strombus Sumatranus*, H. Woodw. (cast). Pl. XIV. Fig. 19.

This specimen is near to, but is not to be identified with the *Strombus Javanus* (also a cast), figured and described by Dr. K. Martin (1879, in Die Tertiärschichten auf Java, p. 47, tab. ix. fig. 2), from Java. It is the cast of a rather ventricose shell, with a slightly produced and costated spire; aperture long, outer lip broadly expanded, ear-shaped, corrugated within, and produced posteriorly into a rounded lobe rising above and separate from the penultimate whorl, notched at the anterior extremity; inner lip striated.

In the *S. Javanus* the outer lip is semicircular and shorter posteriorly, and the spire, which is more produced, numbering about 6 whorls, is smooth.

Dimensions:—Height 25 mm.; breadth 19 mm.

Formation:—In light-coloured Tertiary Clay-marl.

Locality:—Government of the West Coast of Sumatra.

70. *Delphinula fossilis?* K. Martin. Pl. XV. Fig. 1*a*, *b*.

Shell orbicular, depressed; whorls few, angulated distantly and obliquely undulated or costated above, bordered by about 10 spines on the angle of the body-whorl; lirated and transversely striated beneath; peristome continuous, umbilicus open, aperture round, internally nacreous.

Dimensions:—Height 25 millimètres; breadth 35 mm.

The nearest recent form to this species appears to be the *Delphinula sphæra*, of Kiener. It agrees with this shell in general outline and in the swollen undulations on the upper flattened surface of the whorls; but may be distinguished from it by the difference of character in the spines along the superior angle of the volutions, which in *D. sphæra* are very greatly produced, becoming quite branch-like, whilst in the Sumatran fossil they are quite short and much .compressed, resembling in this respect, to some extent, *D. aculeata*, Reeve, an inhabitant of the seas around the Philippine Islands.

Our Sumatran shell also closely resembles, in general appearance, the *D. fossilis* of Martin from Java (Die Tertiärschichten auf Java, 1879, tab. xiii. fig. 4); but the transverse ridges on the last whorl are rather more prominent on our shell than on the Javan fossil, which is, unfortunately, only represented by a broken specimen, so that we cannot fully compare it with this species. In our specimen the longitudinal costæ on the upper surface of the whorls are also somewhat more prominent than in *D. fossilis*.

Formation:—In white Tertiary Clay-marl.

Locality:—Government of the West Coast of Sumatra.

71. *Xenophora agglutinans?* Lamk. Pl. XV. Fig. 2.

The want of all trace of the exterior surface of this shell precludes our determining it with precision. It may, however, be compared with the *Xenophora agglutinans*, Lamarck, figured by Dr. K. Martin in his work on Javan Fossils (tab. xii. fig. 6), and with Vicomte D'Archiac's figure of the *Trochus cumulans*, Brong. (Foss. Numm. de l'Inde t. xxvi. fig. 16). The portion preserved shows 5 to 6 whorls, on which numerous foreign bodies had been agglutinated during the growth of the shell.

Dimensions:—Height 35 mm.; breadth 45 mm.

Formation and Locality:—Found with the preceding species.

72. *Natica*, sp. (cast). Pl. XV. Fig. 3.

This is an imperfect cast of the last whorl of a large and very tumid species of *Natica*; but the want of the spire and any external shell-layer necessarily prevent any accurate description of this fossil.

Formation and Locality:—Found with the preceding species.

73. *Turbo* (*Senectus*) *setosus?* Gmelin, Operculum of. Pl. XV. Fig. 4.

This is almost identical with the operculum of *Turbo setosus*, Gmelin, a species at the present time found living in the Pacific. The differences are so slight that they may be treated more as individual peculiarities than as of specific value. The short granular ridges, for instance, on the exterior, near the inner side just above a groove parallel with the extreme margin, are coarser, and the surface, from the centre to the opposite or outer margin, is less raised, and more coarsely granulated than in the normal form of this operculum. Both have an orange-red stripe bordering the outer edge.

Dimensions:—Greatest diameter 27 mm.; shortest diameter 25 mm.; thickness 13 mm.

Formation and Locality:—Found with the preceding species.

74. *Cassis*, sp. (cast). Pl. XV. Fig. 5.

At first sight this cast appears to be that of a *Natica*, with a somewhat produced spire; but on examining the specimen closely, we at once detect the impressions of denticulations[1] on the interior of the outer lip so characteristic in the genus *Cassis*.

Cast of shell ventricose, spire slightly produced, aperture long, auriculate, outer lip denticulated.

This fossil may be compared with the *Cassis Herklotzii* of Dr. Martin (Die Tertiärschichten auf Java, tab. viii. fig. 7), and also with the figure of *Cassis sublœvigaster*, D'Arch. (D'Archiac and Haime, Foss. Numm. de l'Inde, Pl. 31, fig. 4).

Formation and Locality:—Found with the preceding species.

75. *Neritina subfossilis*, H. Woodw. Pl. XV. Fig. 6, *a*, *b*.

Shell somewhat globose and auriculate, with a depressed and nearly obsolete spire; surface smooth and shining,[2] body-whorl

[1] In figuring this fossil Pl. XV. Fig. 5, the mouth-view only is given, so that one cannot see from the drawing the crenulations or denticulations on the cast, marking what was the character of the interior of the outer lip.

[2] This coloration in the figure (see Pl. XV. Fig. 6, *b*) unfortunately conveys to the eye rather the appearance of corrugations or cross-ridges, but the surface is really quite smooth.

retaining its colour and ornamentation, which consists of concentrically arranged, somewhat elongated white spots upon an olive-brown ground.

The painting of this shell calls to mind that of *N. punctulata*, Lamarck, a living West-Indian species, but the form and columellar region are different. This shell might also be compared with the *Nerita Rumphii* of Martin (see Die Tertiärschichten auf Java, t. xiii. fig. 19).

Dimensions :—Height 7 mm. ; breadth 14 mm.

Formation :—(Subfossil ?[1]) Tertiary.

Locality :—Government of the West Coast of Sumatra.

76. *Neritopsis Morrisianus*, H. Woodw. Pl. XV. Fig. 7, *a*, *b*.

Shell subglobose, neritoid, thick, spire very short and small, surface ornamented with numerous linear tuberculated liræ of nearly equal size, 15 to 16 in number, the tubercles being united to those in the rows above and below them by delicate oblique striæ; aperture subovate, inner margin of outer lip distinctly denticulate ; columellar margin deeply notched.

Dimensions :—Height 11 mm. ; breadth 11 mm.

M. Grateloup, in 1832, established the genus *Neritopsis*, for a fossil shell from the Miocene of Dax, Landes; which he named *N. moniliformis* (Actes de la Société Linnéenne de Bordeaux (tome v. no. 27, p. 125, pl. 3, fig. 1, 2). This species is four times as large as our Sumatran shell, and agrees better with the living *N. radula*, Linn., found in the seas around the Sandwich Islands.[2] From both of these it may, however, be distinguished by its shorter spire, the smaller number of the granular ridges and the coarser liræ within the labrum. The abrupt notch in the columella is of precisely the same form as in the recent species.

The *operculum* of the latter is a comparatively recent discovery. It is of a thick shelly substance, and has a prominence upon the inner side, which fits into the notch in the columella. It is described by M. Souverbie (Journ. de Conchyliologie, 1874, vol. xxii. p. 199), and in the succeeding volume of the same work by M. Crosse. The curious fossil organisms from the Upper Lias of Normandy (Soâne-et-Loire and Calvados), from Württemberg, and from the Coral-Rag of England, upon which MM. Eudes and Eugéne Deslongchamps founded their genus *Peltarion* in 1859, are only the opercula of a species of *Neritopsis*.[3] The operculum of *Neritopsis* has also been named *Scaphanidia* by J. Müller. Mr. Ralph Tate observes[4] of the genus *Peltarion*, that it is "Founded on the mandibular armature of *Tetrabranchiate Cephalopods*."

[1] The fresh condition and coloration of this shell render it difficult, in the absence of more exact knowledge of these beds, to refer it to any but a very modern deposit.

[2] Twenty fossil species of *Neritopsis* are described from the Trias?, Lias, and Oolites. Dr. Hörnes has also figured a *Neritopsis* (which he refers to the recent *N. radula*) from the Vienna Basin. I find that Hörnes considers Grateloup's *N. monilifera* to be only a synonym of *N. radula* (Foss. Moll. des Wiener Beckens, p. 528, pl. 47, fig. 8).

[3] See Jules Beaudouin (Bull. Soc. Géol. France, 2e série, t. xxvi. 1869, p. 182).

[4] Manual of Mollusca, by Dr. S. P. Woodward, *Appendix* by *Ralph Tate*, 1875, pp. *12 and *13, fig. 11.

I beg leave to dedicate this interesting Tertiary representative of a Mesozoic genus, now almost extinct, to my valued friend and colleague Prof. John Morris, M.A., F.G.S., whose stores of palæontological knowledge are always so freely accessible to all his scientific friends, and who has rendered me much valuable assistance in preparing the present memoir.

Formation :—Tertiary Clay-Marl.

Locality :—Government of the West Coast of Sumatra.

77. *Melania subfossilis*, H. Woodw. Pl. XV. Fig. 8, *a*, *b*.

Shell fusiform, surface smooth, with fine longitudinal striæ; whorls 7 in number, spotted around the suture with brown spots; body-whorl with occasional brown streaks; earliest volutions of spire distinctly costated; suture strongly marked; lower part of body-whorl distinctly lirated; aperture entire, oval, pointed behind, outer lip thin.

This shell, like the *Neritina* already noticed, has all the appearance of having been living at a very recent date.

It is probably near to the *Melania* (*Aulacostoma*) *lævissima*.

Dimensions :—Height 12 mm.; breadth 7 mm.

Formation :—(Subfossil ?) Tertiary.

Locality :—Government of the West Coast of Sumatra.

78. *Melania rivularis ?* Philippi. Pl. XV. Fig. 9, *a*, *b*.

The following is Philippi's description of this species:—Shell turrited, greenish; apex decollated, whorls 7, convex, suture strongly marked; transversely striated, the upper whorls marked with red lines, the middle series with transverse spots below the suture; aperture ovate-oblong, acute above, base expanded; lip near the base somewhat produced (length 20 mm.; breadth, 6 mm.), (Abbildungen und Beschreibungen Conchylien von Dr. R. A. Philippi, band. ii. lief. 6, Cassel, 1847, 4to.)

The shell here figured agrees very well indeed with Philippi's description of *Melania rivularis*, but differs somewhat from his figure, which represents the whorls a trifle less convex and the aperture a little more elongated and produced at the base. *M. rivularis* is a Javanese form. *M. fontinalis*, of Philippi, is another closely-related species, and in fact (as suggested by the author himself) may probably only be a local variety of the preceding species. It is found in the aqueducts in the Island of Pulo Pinang.

Dimensions :—Height 16 mm.; breadth 5 mm.

Formation :—(Subfossil ?) Tertiary.

Locality :—Government of the West Coast of Sumatra.

79. *Melania* ? (cast). Pl. XV. Fig. 10.

This specimen makes us acquainted with an elongated cast showing six convex volutions carinated near the suture; none of the shell is preserved save the inner layer.

This cast might be compared with that of the *Turritella Subathooensis*, D'Arch. (D'Arch. and Haime, Numm. Foss. de l'Inde, t. 28, fig. 1), with which it agrees in general form.

If this be the internal cast of a *Melania*, of which there seems little doubt, it affords some grounds for assuming that the very recent-looking *Melania* shells (Figs. 8, 9, 11, 12, and 13) may, after all, prove to be exceedingly well-preserved fossils from the same series of clays of Tertiary age.

Dimensions of cast:—Height 60 mm.; breadth 25 mm.

Formation:—From white Tertiary Clay-marl.

Locality:—Government of the West Coast of Sumatra.

80. *Melania pyramis* (Benson), Reeve. Pl. XV. Fig. 11 *a, b.*

Shell elongated, fusiform, whorls 9–10 in number, slightly convex, finely striated spirally, maculated, smooth, suture very distinct; body-whorl nearly equalling the height of the spire; aperture entire, oval, pointed above, outer lip sharp, columella smooth.

Dimensions:—Height 20 mm.; breadth 7 mm.

My colleague, Mr. Edgar Smith, has kindly assisted me in the examination of this shell, which agrees very well in most of its characters with the *Melania pyramis* (Benson, Reeve, Conchologia Iconica, xii. sp. 51), a Bornean species, the type of which is preserved in the British Museum. The spiral sculpture is much the same in character, but is only obsolete on a part of the last whorl, and not altogether absent, as described by Reeve. In this statement he is scarcely justified, for on carefully examining the figured specimen, a few spiral striæ can be distinctly traced; two other recent examples are sculptured to the same extent on the last three or four whorls, as in the Sumatran specimen; both the Bornean and Sumatran shells agree in having a deeply canaliculated suture.

Formation:—(Subfossil ?) Tertiary.

Locality:—Government of the West Coast of Sumatra.

81. *Melania sublactea*, H. Woodw. Pl. XV. Fig. 12.

Shell elongated, fusiform, whorls nine in number, somewhat convex; body-whorl equalling the height of the spire; without colour-bands or ornamentation, save fine longitudinal striæ; suture distinct, aperture somewhat small, entire, oval, pointed posteriorly; outer lip sharp, columella smooth.

Dimensions:—Height 17 mm.; breadth 7 mm.

This shell resembles the *Melania lactea* in form, but the whorls are less in number (7), and are not quite so convex; the columellar border of the recent shell is thickened, which is not the case with the fossil one.

Formation:—(Subfossil ?) Tertiary.

Locality:—Government of the West Coast of Sumatra.

82. *Melania costata*, Quoy and Gaimard, 1834.

Melania costata, var. *glabra*, H. Woodw. Pl. XV. Fig. 13.

Shell subulate, elongated; spire acute; whorls 9, *smooth*, slightly striped beneath the suture; upper volutions ornamented with fine spiral striæ, body-whorl nearly equal in height to the spire.

Dimensions:—Height 56 millimètres; breadth 15 mm.

The shell here figured appears inseparable from the *Melania costata* of Quoy and Gaimard, 1834 (Voyage de l'Astrolabe, Zoologie, tome iii. p. 155, pl. 56, figs. 34–37), *one of the most variable species* in form and sculpture of the whole genus. Certain specimens in the

British Museum from the Philippine Islands are just of the same smooth unplicated or uncostated character, with similar fine spiral striæ on the upper volutions, and painted with the same short reddish stripes just beneath the suture, as in the Sumatran shell. The lip of the latter is considerably broken away, and consequently displays a less patulate aperture, and a different curve at the columella.

Formation:—(Sub-fossil ?) Tertiary.

Locality:—Government of the West Coast of Sumatra.

83. *Dentalium*, sp. Pl. XV. Fig. 14.

This is a fragment only of a smooth form of *Dentalium*, but the specimen is too fragmentary for description.

Formation:—In light-coloured Tertiary Clay-marl.

Locality:—Government of the West Coast of Sumatra.

In concluding this description of M. Verbeek's Fossils, I must beg leave to tender my best thanks to my colleague, Mr. Edgar A. Smith, of the Zoological Department, for his many notes and suggestions with regard to recent species; also to my friend Prof. Morris, M.A., for his kindly and valuable assistance in preparing this paper for publication.

At the suggestion of Professor T. Rupert Jones, F.R.S., F.G.S., the whole of the specimens sent from Sumatra by M. R. D. M. Verbeek have, with the sanction of the Dutch-Netherland Government, been presented to the British Museum, where they are preserved for reference.

EXPLANATION OF PLATES XIV. AND XV.

Plate XIV.

Fig.	1.	*Triton* (cast of).	In Grey Tertiary Clay-marl,	Govt. West Coast Sumatra.
,,	2.	*Pleurotoma terebra*, Bast.	In Bluish Tertiary Clay-marl;	*loc. cit.*
,,	3.	,, *concinna*, Dunker.	,,	,,
,,	4.	*Phos Borneensis*, Sby.	,,	,,
,,	5.	*Turbinella subcostata*, H. Woodw.	,,	,,
,,	6.	*Pisania subdiscolor*, H. Woodw.	,,	,,
,,	7.	*Ranella ? tritonoides*, H. Woodw.	,,	,,
,,	8.	*Borsonia granifera*, H. Woodw.	,,	,,
,,	9.	*Cerithium Verbeekii*, H. Woodw.	,,	,,
,,	10.	*Pleurotoma Jonesiana*, H. Woodw.	,,	,,
,,	11.	*Ranella ?* sp. (cast).	In white Tertiary Clay-marl,	,,
,,	12.	*Turbo Smithii*, H. Woodw.	,,	,,
,,	13.	,, *Sumatrensis*, H. Woodw.	Tertiary,	,,
,,	14.	*Monodonta submamilla*, H. Woodw.	,,	,,
,,	15.	*Solarium Javanum ?* Martin.	In bluish Tertiary Clay-marl,	,,
,,	16.	*Turbo Martinianus*, H. Woodw.	In white ,,	,,
,,	17.	*Turritella*, sp.	In bluish Tertiary Clay-marl,	,,
,,	18.	*Cerithium*, sp.	,,	,,
,,	19.	*Strombus Sumatranus*, H. Woodw.	In white ,,	,,

Plate XV.

Fig.	1.	*Delphinula fossilis ?* K. Martin.	White Tertiary Clay-marl,	Government West Coast Sumatra.
,,	2.	*Xenophora agglutinans ?* Lamk.	,,	*loc. cit.*
,,	3.	*Natica*, sp. (cast).	,,	,,
,,	4.	*Turbo setosus ?* (operculum of).	,,	,,
,,	5.	*Cassis*, sp. (cast).	,,	,,
,,	6.	*Neritina subfossilis*, H. Woodw.	Tertiary,	,,

Fig. 7.	*Neritopsis Morrisianus*, H. Woodw.	Clay-marl, Tertiary,	*loc. cit.*
„ 8.	*Melania subfossilis*, H. Woodw.	Tertiary,	„
„ 9.	„ *rivularis ?* Philippi.	„	„
„ 10.	„ ? (cast of).	White Tertiary Clay-marl,	„
„ 11.	„ *pyramis*, Benson.	Tertiary,	„
„ 12.	„ *sublactea*, H. Woodw.	„	„
„ 13.	„ *costata*, var. *glabra*, H. Woodw.	Tertiary,	„
„ 14.	*Dentalium*, sp.	Tertiary Clay-marl,	„

NOTICES OF MEMOIRS.

I.—"Limestone as an Index of Geological Time." By T. Mellard Reade, C.E., F.G.S. [From the Proceedings of the Royal Society, No. 192, 1879.]

THE geological history of the globe is written only in its sedimentary strata, but if we trace its history backwards, unless we assume absolute uniformity, we arrive at a time when the first sediments resulted from the degradation of the original crust of the globe.

There is no known rock to which a geologist could point and say "that is the material from which all sedimentary rocks have been derived," but analogy leads us to suppose that if the earth had an igneous origin, the original materials upon which the elements first began to work were of the nature of granite or basalt.

From a variety of considerations drawn from borings, mines, faults, natural gorges and proved thicknesses of the strata of certain mountain chains, the author arrives at the conclusion that the sedimentary crust of the earth is at least of an average actual thickness of one mile, and infers from the proportionate amount of carbonates and sulphates of lime to materials in suspension in various river waters flowing from a variety of formations, that one-tenth of the thickness of this crust is calcareous.

Limestone rocks have been in process of formation from the earliest known ages, but the extensive series of analyses of water made by Dr. Frankland for the Rivers Pollution Commission, shows that the later strata in Great Britain are much more calcareous than the earlier. The same holds true of the continent of Europe, and the balance of evidence seems in favour of the supposition that there has been on the whole a gradual progressive increase or evolution of lime. The "Challenger" soundings show that carbonate of lime in the form of tests of organisms is a general deposit characterizing the greater part of the ocean bottoms, while the materials in suspension are, excepting in the case of transport by ice, deposited within a distance of 200 miles of land.

This wider distribution in *space* of lime, the author thinks, must also profoundly influence its distribution in *time*, and he shows this by example and illustration. It can also be proved to demonstration that the greater part of the ocean bottom must at one time or another have been land, else the rocks of the continents would have become gradually less, instead of more, calcareous.

Thus the arguments drawn from the geographical distribution of animals are reinforced by physical considerations.

The author goes on to show that the area of granitic and volcanic rocks in Europe and the part of Asia between the Caspian and the Black Sea, as shown in Murchison's Map of Europe, is two-twenty-fifths ($\frac{2}{25}$) of the whole; much of this is probably remelted sediments, and some of the granites the product of metamorphism.

From considerations stated at length, it is estimated that the area of exposures of igneous to sedimentary rocks would be for all geological time liberally averaged at one-tenth ($\frac{1}{10}$) of the whole.

These igneous rocks are either the original materials of the globe protruded upwards, or they are melted sediments or a mixture of the two.

The only igneous rocks we know of are of the nature of granites and traps. If these rocks do not constitute the substratum of the earth, and all known rocks, igneous as well as sedimentary, are derivative, either geological time is infinite, or the rock from which they are derived is, so far as we know, annihilated geologically speaking, and we have no records of it left.

If we assume the latter as true, the past is immeasurable, but in order to arrive at a minimum age of the earth, the author starts from the hypothesis that the fundamental rocks were granitic and trappean.

From eighteen analyses by Dr. Frankland, it is shown that the water flowing from granitic and igneous rock districts in Great Britain contains on an average 3·73 parts per 100,000 of sulphates and carbonates of lime.

The amount of water that runs off the ground is given for several of the great continental river basins in Europe, Asia, Africa, and America. The annual depth of rain running off the granitic and igneous rock areas, taking into consideration the greater height at which they usually lie and the possibility of greater rainfall in earlier ages, is averaged at 28 inches, and the annual contribution of lime in solution in the forms of carbonates and sulphates at 70 tons per square mile.

With these elements, and giving due weight to certain physical considerations that have been urged in limitation of the earth's age, the author proceeds to his calculations, arriving at this result, that the elimination of the calcareous matter contained in the sedimentary crust of the earth must have occupied at least 600 millions of years. The actual time occupied in the formation of the groups of strata as divided into relative ages by Prof. Ramsay, is inferred as follows:—

	Millions of Years.
Laurentian, Cambrian, and Silurian	200
Old Red, Carboniferous, Permian, and New Red	200
Jurassic, Wealden, Cretaceous, Eocene, Miocene, Pliocene, and Post-Pliocene	200
	——600

The concluding part of the paper consists of answers to objections. The author contends that the facts adduced prove geological time to be enormously in excess of the limits urged by some physicists, and ample to allow on the hypothesis of evolution for all the changes which have taken place in the organic world.

II.—Fossil Forests of the Yellowstone Park.

Mr. W. H. HOLMES has given a brief but interesting account of the volcanic Tertiary beds of the Yellowstone region (Bull. U. S. Geol. and Geog. Survey of the Territories, vol. v. p. 125), which are stated to cover or to have covered an area of not less than 10,000 square miles. The chief materials consist of volcanic fragments apparently distributed by water, and now form breccias, conglomerates, and sandstones, and contain an abundance of silicified wood. Where typically developed, as in the valley of the East Fork, they have a thickness of 5,000 feet, and rest upon eroded surfaces of granitic and Palæozoic rocks. The lowest observed occurrence of these beds is in the valley of the main Yellowstone, between the first and second cañons, at an elevation of about 5,000 feet above the level of the sea. They appear to be destitute of animal remains, but the greater part of this immense group of strata is filled with the silicified remains of a multitude of forests. The roots and stems are found *in situ,* and prostrate trunks are of frequent occurrence, besides branches, leaves, and fruits. These old forests are well exposed at successive levels in the 2,000 feet of strata exposed on the north face of Amethyst Mountain, and from the character of the vegetation, Prof. Leo Lesquereux considers the strata to belong to the Lower Pliocene or Upper Miocene. In many cases the wood is completely opalized or agatized, and the cavities are filled with beautiful crystals of calcite, quartz, and amethyst. J. M.

III.—Report on the Stormberg Coal-field. By Mr. E. J. Dunn. 4to. pp. 36. (Solomon & Co., Cape Town, 1878.)

Mr. DUNN describes the constituent strata of the Stormbergen as—at top—1. Volcanic: lavas, tuff, agglomerate, ash-beds, and amygdaloids, with volcanic bombs in sandstone, about 400 feet. 2. Cave-sandstone: buff-coloured, pinkish, greenish, white and grey, fine-grained, thick-bedded sandstone; about 150 feet; with fragments of Sauroid bones. 3. Red beds: friable, red and purple, arenaceous shale, and similar sandstone, mottled green, alternating with grey felspathic sandstones, also conglomerate (p. 8); about 600 feet; with Sauroid bones; and fossil wood in the lower beds, scarce. 4. Coal-measures: grey and light-coloured sandstones, generally felspathic, alternating with shales, in which coal-seams occur, and conglomerates; about 1,000 feet; carbonized plant-remains abundant in the sandstones, ferns in the shales; fossil wood abundant; fossil bones very rare. Doleritic dykes penetrate the whole series. The "Stormberg" strata, he says, continue throughout the Drackensberg range, and the series is as strongly marked near Harrismith as in the Stormbergen. They lie conformably on red, greenish, and grey shales, with grey sandstones, rich with Dicynodont and other reptilian remains. Mr. Dunn separates the latter series, as "Upper Karoo Beds," from the former (as "Stormberg Beds"); but why the whole should not remain, as heretofore, as parts of the great "Karoo Formation" of A. G. Bain, is not at all clear.

The Coal-bearing beds of the Stormberg as seen on the north side (Albert), and the conditions of working, are described at pages 5 and 6 and 16–33. The seams of coal are not numerous nor thick; the aggregate being not more than 6 feet 6 inches, at Bushman's Hoek and the Indwe River, with 4 feet more represented by "one or two thin seams of inferior coal, occupying a higher position in the series," a few miles to the south. Ferns from the coal-shales are identified (p. 19) with *Pecopteris odontopteroides* (p. 11), *Cyclopteris cuneata*, and *Tæniopteris Daintreei* of Queensland.

The "Red Beds" are described at pages 7–9. The "Cave Sandstone," described at pages 9 and 10, forms conspicuous precipices, being at some places a solid freestone more than 150 feet thick, almost without any lines of bedding. Water, running over its edge, or oozing out from beneath, forms the numerous caves to which it owes its name. One of these is 330 feet wide at the entrance, 144 feet deep, 60 feet high at mouth, lessening to nothing at the back of the cave. The kloofs (gorges), krantzes (precipices), kops (little hills), blocks, caves, and fantastical masses (pulpit-rocks, etc.), of this sandstone give rise to picturesque and sometimes grand scenery. The felspathic material in this sandstone, acted on by infiltrating rain-water, gives the calcareous stalagmite (drip-calc) seen in some of the caves and krantzes. In this sandstone, as in the "Coal-measures" and "Red-beds," ripple-marks and mud-cracks are present, also "tracks of crustaceans."

The "Volcanic rocks" are described in detail at pp. 10–16. "Two of the cores still preserve a crater-like form;" these are of very great interest, and are "Glat Kopjes" and "Telemachus Kop." Pipes, throats, flues, plugs, etc., of old volcanos are also met with among the "Stormberg beds" in the Nieuwveldt and Karreebergen (near Caernarvon). The numerous dykes of igneous rock all over the region are referred to; also the agate-gravel of many rivers of South Africa is noticed as having been derived from the amygdaloids; and the origin of "pipe-agate," as due to the uprise of steam in hot vesicular and siliciferous lava from the damp ground over which it flowed, is concisely stated among other interesting facts connected with this division of South-African Geology.

We may mention that in the "Cape Monthly Magazine," new series, vol. ii. 1873, p. 60, is Mr. Dunn's earlier report on the Stormberg Coal; and that Mr. Evans, of Queenstown, has given some useful notes on the Stormberg Coal as known in 1870 (see the "Mining Journal," January 14, 1871); also that Mr. G. W. Stow, F.G.S., has described and illustrated the Geology of Dordrecht and other places north and south of the Stormberg, in the Quart. Journ. Geol. Soc. vol. xxvii. 1871, pp. 523, etc.

In conclusion, Mr. Dunn states (p. 32):—"The tract of country over which coal-outcrops may be expected to occur on the South slopes of the Stormberg, lying between Bushman's Hoek and the Indwe, has not been examined. From the position the coal-measures occupy, it is clear that coal-outcrops will be found right round the base of the Drackensberg, and equally clear that the seams are thicker and the quality better the further they occur to N.E. from the

Stormberg. In Natal, at Biggar's Berg, is a seam of coal, eight feet thick, of better quality than the Stormberg coal. In the Transvaal equally thick seams of superior coal are known in the High Veldt. A few outcrops are known in the Free State. Properly directed explorations would result in tracing the outcrops through Kaffirland, Natal, the Transvaal, and Free State. In the higher parts of Basutoland, and, in fact, along the higher portions of the Drackensberg chain and its spurs, no coal will be found; the seams do not occur at such altitudes." T. R. J.

IV.—Report on the Camdeboo and Nieuweldt Coal, Cape of Good Hope. By E. J. Dunn, Esq. 4to. pp. 24, with several Sections and Plans. (Solomon & Co., Cape Town, 1879.)

THE occurrence of two sets of Coal-bearing beds on the N.E. margin of the Stormberg (near Bushman's Hoek), north of Queenstown,—one of probably old "Carboniferous" age, and the other belonging to the upper part ("Stormberg") of the great Karoo Series, —was indicated in the Quart. Journ. Geol. Soc. 1871, vol. xxvii. p. 52; and, though the Report above noticed does not support that view, something like it is now proved to be the case at about 150 miles W. by S. from Queenstown. Mr. Dunn has found an exposure (*inlier*) of some underlying coal-bearing (anthracitic) strata, distinct from the surrounding and unconformable Karoo Beds, at Buffel's Kloof, on a spur of the Camdeboo Mountains, between Graaf-Reinet and Beaufort West; and again at Brandewyn's Gat, by the Leeuwe River, on a spur of the Nieuwveldt, 36 miles N.W. of Beaufort West, and 100 miles W. of Buffel's Kloof. By making careful sections of the strata between Beaufort and Graaf-Reinet, and by examining the sections opened out by the new railway running S.W. from Beaufort, across the Dwyka, Bloed, and Buffel's Rivers and the Wittenberg range, Mr. Dunn has fully explained the relation of the horizontal Karoo series as unconformable to the underlying tilted, folded, and broken "Ecca Beds," with their inclosed and conformable "Dwyka Conglomerate" (Dunn). This remarkable rock, once thought to be of igneous origin ("Trap-breccia," etc.), is now known to be composed of dense sandy mudstone and blocks, and to be probably of glacial origin. Having thus successfully traced these Ecca Beds, from the (Devonian or Carboniferous) sandstones of the Witteberg, with which they are conformable, to the Camdeboo district, Mr. Dunn shows good reason why the inlier of highly inclined coaly rocks under the horizontal Karoo beds there are part of the Ecca group; and the more so because anthracite and a highly carbonaceous limestone occur in one part of that group of strata near Buffel's River on the Beaufort and Cape-Town line of railway.

The author, however, is not correct in stating that the Karoo Beds have always been supposed to be conformable to the Ecca Beds. In 1857 and 1858 ('Eastern Province Monthly Magazine,' No. 17, December, 1857, p. 187, and Quart. Journ. Geol. Soc. vol. xv. pp. 197, 198) the late Dr. Rubidge argued that in the Eastern Province of Cape-Colony the "plant-beds of Ecca" (the lower portion, at least) were of *Devonian* age, that they did not belong to the Karoo series, and that the latter abutted against them unconformably; and these conditions are expressed in Mr. Pinchin's sections in the Quart. Journ. Geol. Soc., vol. xxxi. 1874, p. 106, pl. 4.

At Buffel's Kloof the diggings and shaft clearly show that one or more rather thick seams of coal (anthracite) in the underlying inclined beds have been broken and crushed by a fault, and even forced up into the higher fissures contained in the overlying horizontal Karoo beds, which do not hereabouts contain coal. The shales in which the coal is bedded contain "Glossopteris and Calamites." The value of these fossils in proving the exact age of the bed depends on many circumstances; and, although not quite so good as the *Lepidodendron* and *Sigillaria* from the northern margin of the Stormberg, yet *Calamites*, at least, evidently belong to beds below the Karoo Series, and *Glossopteris* may be old "Carboniferous," as in Australia.

Ecca shales with plant-remains in the Eastern Province, and fossil wood on the Pataties and anthracite on Buffel's River, in the West, indicate this to be a carbonaceous formation. Mr. Dunn suggests that there may be plenty of good coal in the covered-up "Ecca Beds" of the Camdeboo and neighbouring hills, to be found by judicious boring; and, although the exposures now known show only crushed anthracite, not only the crushing, but the metamorphic change from coal (hydrocarbon) to anthracite (carbon) may there be due, as elsewhere, to local pressure and disturbance.

The descriptions and sections in this Report elucidate the nature and relative positions of the Ecca Beds (pages 6–10), and of the lower portion of the Karoo series (pages 10–24), omitting the Stormberg portion, well described in the foregoing Report, very satisfactorily, and thus add very much to our knowledge of South-African Geology.

T. R. J.

REVIEWS.

I.—Chemical and Geological Essays. By Thomas Sterry Hunt, LL.D. Second edition. (London, Trübner & Co., 1879).

THE recent issue of a second edition of Dr. Sterry Hunt's Chemical and Geological Essays, which first appeared as a separate volume in 1875, affords a fitting opportunity for noticing some of the questions with which the author is so well qualified to deal. The work consists of a series of papers published in various scientific journals during the last twenty years, which are now reproduced more or less verbatim, with short introductory notes occasionally prefixed by way of explanation. There are twenty essays in all, dealing with a variety of subjects, most of which may be grouped under the following heads:—

1. Chemical and dynamical speculations on the early condition of the planet, and on subsequent volcanic phenomena.
2. History of the crystalline rocks.
3. Essays in chemical geology not directly related to either of the above subjects.

4. Purely chemical and mineralogical essays.

Some of these essays have appeared in the columns of this MAGAZINE, and we may, therefore, suppose that many of our readers are familiar with them; but as the first and second group of essays deal with subjects which have been provocative of constant and progressive discussion, a brief notice of some of the points on which they touch may not be without interest.

Chemical and dynamical speculations, etc.—A vision of chemical cosmogony is presented to us about the period in the general history of Kosmos, when the partially cooled globe—our planet—began to settle down to what must always be a subject of interest to a geologist, viz. the formation of the nearest approach to rocks we can conceive. Two principal hypotheses have been maintained with respect to this consolidation. 1. That of a solid crust resting on an uncongealed nucleus. This is perhaps the view which has been most generally believed. 2. That solidification commenced at the centre, and advanced towards the circumference, but that at the close of this process a condition of imperfect liquidity supervened, resulting in the formation of a superficial crust which retained a liquid zone between itself and the solid centre. This portion of uncongealed matter would be the seat of volcanic action, the evident facts of a flexible crust requiring something of this sort.

In the lecture which he delivered at the Royal Institution in May, 1867, "On the Chemistry of the Primeval Earth," Dr. Sterry Hunt adopted the theory of a solid crust, partly on the grounds that "numerous and careful experiments show that the products of solidification (always excepting water) are much denser than the liquid mass." To this view the late lamented David Forbes took exception, as indeed he did to almost every point in our author's lecture. The consequence of this was a somewhat embittered controversy carried on between these eminent geological chemists, for the most part in the pages of this MAGAZINE. That was a time when few persons in this country availed themselves of chemistry and the allied sciences in the study and grouping of the rock-masses; a time when almost any rock that was green might be put down as a "greenstone," and when the numerous analyses which had been made on the Continent and in America were almost unknown to our geologists. The return of David Forbes from a long sojourn in foreign countries was marked by a not unsuccessful effort on his part to assert the importance of chemical geology. He thus acquired great and well-merited influence in fashioning and controlling opinion in this country on all points relative to the chemistry of rocks.

Although doubtless Dr. Sterry Hunt laid himself open to criticism in some respects, as, for instance, when he states that "quartz can only be generated by aqueous agencies and at comparatively low temperatures," it may be questioned whether Forbes was particularly happy in his criticisms or in the reasons by which he sought to enforce them. Let us take, for instance, his appeals to the results seen on a small scale in the cooling of melted metals; where, as observed by Hunt, the conditions of a liquid congealing in an atmosphere greatly below its own temperature, and having a crust growing out from and supported by the sides of the vessel, are widely different from those of a liquid globe slowly cooling beneath a very dense and intensely-heated atmosphere.

The composition of the Earth's crust and atmosphere are the next subjects discussed. The original crust, says Sterry Hunt, is now everywhere buried beneath its own ruins, and he considers that it must have resembled certain furnace slags or volcanic glasses, whilst the primeval atmosphere would contain all the carbon, chlorine, and sulphur in the form of acid gases with nitrogen, watery vapour, and a probable excess of oxygen. Forbes took strong objection to these speculations, especially as regards the primitive atmosphere. No excess of oxygen, he said, could exist with so much sulphurous acid; moreover, hydrochloric and sulphurous acids at high temperatures decompose each other with the formation of water, chlorine and sulphur. From the affinity of sulphur for the metals, and from the fact that sulphurous acid is decomposed by metals with the formation of sulphides and oxides, he infers that this element (sulphur) in reality united itself to the metals, and thus formed dense sulphides which at once sank through the lighter fluid layer. So far as he confined himself to criticisms, especially on the action of sulphur, Forbes was pretty safe; but in his reply he unfortunately ventured on the production of a rival atmosphere in zones, where, as eagerly pointed out by his opponent, he forgot the specific gravities of some of his gases, and altogether ignored the law of their diffusion. Those who care to pursue this subject further will find the several papers in the Geological Magazine. (See 1867, Vol. IV., pp. 357, 433, and 477, and 1868, Vol. V., pp. 49, 92, 93, 106, and 366.)

The subject of the earlier condition of the atmosphere is again discussed by Dr. Hunt in the preface to the second edition, and he alludes especially to the probabilities that even a very moderate extra amount of carbonic acid in the atmosphere would diminish loss of heat from radiation. He recalls to the minds of his readers the enormous amount of carbonic acid now locked up in the earth's limestones, equal in weight to 200 of the present atmospheres. The progressive diminution in the height of the atmospheric column has been due to its elements having been condensed in the form of liquid water, or fixed as hydrates, oxides, or carbonates; hence a gradual refrigeration of the earth's climate. The application of these views is, he observes, contrary to the hypothesis of an alternation of warm and glacial climates in past ages, but is more in accordance with the facts of the geological story, where everything tends to show that a warm climate prevailed *everywhere at the sea-level.* (Read in conjunction with the highly suggestive and ingenious hypothesis propounded by Mr. Ball at the Royal Geographical Society in June last, which "really took Sir J. Hooker's breath away," we may believe that we have now obtained some clue to the history of the earth's climate in time, which has been so long obscured by ice on the brain.) The amount of carbonic acid which the life of the successive ages could endure presents however the chief difficulty, and is a physiological question which must doubtless be answered.

In discussing "The probable seat of Volcanic Action," Dr. Hunt alludes to a modification of the theory of the liquid zone between the solid core and the crust, which he is inclined to adopt, whilst accepting in the main the theory of Hopkins. This theory of Sterry Hunt is Neptunean in the highest possible degree, but there is one point on which he has always been staunch—viz. that the originating heat is derived from the central mass. Indeed, he thinks it probable that any chemical processes which may be set up in the buried sediments for their conversion into igneous rocks and volcanic products would absorb rather than generate heat. As some people, perhaps from an instinctive dread of telluric heat, have exercised much ingenuity of speculation on the causes of the heat of vulcanicity, it is satisfactory to find that Hunt, though a Neptunist, has no difficulty on this point. But he considers that, although in early times a yet unsolidified sheet of molten matter may have existed between the solid core and the superficial crust, such is not now the case. He believes that the cushion on which the flexible crust undulates is in fact the base of that crust impregnated with water and in a state of aquo-igneous fusion. When there is an excess of pressure, this may tend to produce fluidity — the very reverse of Scrope's idea that relief of pressure effected this. Hence also the belief of Hunt that the phenomena of volcanic eruptions are the most likely to occur under the more recent formations, where he appears to conceive that there is the greatest amount of pressure, and he endeavours to show, though perhaps not very successfully, that the present distribution of volcanic areas favours this view. Certainly the ancient volcanos in Auvergne and the Eifel, piercing as they did rocks of high antiquity, do not substantiate his case; and this is the more important, as Dr. Hunt seems to predicate for the old crystalline areas an immunity from volcanic disturbance in future.

The composition of the semifluid cushion is of course all important. The existing crust being the water-deposited débris of the primeval slag mixed with such precipitates as have from time to time been abstracted from the liquids which condensed upon it, contains all the substances and may yield all the phenomena of volcanic eruptions. Hence it may be deemed self-containing, and requires no reinforcement from below, the central solid core acting merely as a stove to supply heat. There is no necessity therefore for the acidic and basic magmas of Durocher and others, and the admitted division of the rocks, both volcanic and crystalline, into what corresponds on the whole to trachytic and doleritic, is capable of another explanation, which also will better accord with the complex nature of the rocks themselves. Such a separation has in fact been going on from the very earliest times, owing to the effects of atmospheric waters, which remove from the rocks soda, lime, and magnesia, leaving behind silica, alumina and potash—the elements of granitic and trachytic rocks. This action is more or less complete, according to the permeability of the rocks, and thus arises a tendency to a division into two classes of silico-argillaceous rocks constituting the bulk of the earth's crust,—doubtless an ingenious suggestion, though hardly meeting cases such as that of the abundance of alumina in anorthic felspars.

In 1873 we find Dr. Sterry Hunt complaining that, in his endeavours to reconstruct dynamical geology on a new basis since 1858, his views have been appropriated without acknowledgment by Le Conte, Mallet, and others. Le Conte, we are told, says that the whole theory of igneous agencies must be reconstructed *on the basis of a solid earth*, a view adopted, and ably defended, but not originally propounded, by Hunt, who takes the opportunity of pointing out that his theory of the plastic zone of sediments affords the necessary cushion between the outer crust and the rigid central mass. There are, it must be admitted, instances when people appropriate the doctrines of others, after having opposed something like them for years, and this may occur both in the political and scientific world. But we must also bear in mind that great ideas are epidemic, and that discoveries have at times been announced almost simultaneously from different quarters. The question of priority is often rather delicate, though in one instance at least, as Professor Dana has admitted with characteristic candour, Dr. Sterry Hunt's claims to priority were incorrectly denied.

History of the crystalline rocks.—This subject is so bound up on the one hand with the questions already discussed, and on the other with the geognosy of extensive areas both in the Old and New World, that it may be regarded as a sort of connecting link between the previous speculations and pure geology. Most of the former questions are likely to remain open for some generations to come; but in the history of the crystalline rocks we have more accessible ground for discussion, and the subject is one in which geologists can take an especial interest. Our author's general declaration of faith has appeared so recently in this MAGAZINE (GEOL. MAG. for 1878, p. 466), that a very brief epitome will meet the case, viz. that the various "crystalline stratified rocks are not plutonic, but neptunean in origin, and, except so far as they are mechanical sediments coming from the chemical or mechanical disintegration of more ancient rock-masses, were originally deposited as, for the most part, chemically formed sediments or precipitates, in which the subsequent changes have been simply molecular, or at most confined to reactions, in certain cases, between the mingled elements of the sediments." He claims that some of the most enlightened students now favour the neptunean origin of rocks; one of the most notable examples being that of Delesse, at one time a pillar of the metamorphic school, who has recently criticized the views of Von Lasaulx and Knop with regard to wholesale metasomatic changes, which Delesse designates as *métamorphisme à l'outrance.* Hunt further quotes Delesse as objecting to the idea of orthoclase being connected on the one hand with the volcanic mineral leucite—from which the transmutationists would derive it—and on the other hand with potash-mica supposed to be formed from the orthoclase. He challenges his reader to compare the above citations from Delesse with his own language on the doctrines of pseudomorphism by alteration as applied by some who would maintain the possibility of converting almost any silicate into any other (*vide* also p. 324 *et seq.*). Finally, at the close of the preface to the second edition of his Essays, he expresses his belief that J. D. Dana has abandoned his former opinions on metamorphism, though not to the extent that might be desired.

The essay on Granite and Granitic Veinstones (1871-1872) is a very useful contribution. Dr. Hunt's experiences are chiefly derived from the Green and White Mountain Series, and from the Laurentians in Canada and New York State. The distinction between granite and gneiss must be made chiefly on geognostical grounds. As regards granitic veins, the notion that all are the result of some process of injection is a general one, though the author has pointed out that some are concretionary and of aqueous origin. He would call these rather endogenous, to distinguish them from intrusive or exotic rocks (such as granitic dykes) and from sedimentary or indigenous rocks. They are in fact, according to this view, exfiltration veins, and vary from a few inches (sometimes an isolated nodular mass almost like a geode) to 60ft. or more. Such veins, to judge from numerous descriptions given by him, often exhibit a banded structure with alternations of minerals, as quartz and felspars (chiefly orthoclase), and frequently contain fine crystals of different minerals, chiefly silicates. It is no great strain upon our faith to believe in exfiltration as the origin of hydrated silicates, as zeolites; but to attribute to such quantities of anhydrous silicates a concretionary origin is a bolder conception. Yet it is evident to any one who has studied a veined gneiss in section that there do occur geodic cavities and strings filled with bands of quartz and felspar in large masses, which seem to be cut off and isolated. The difficulty in these cases has always been to understand how the apple got into the dumpling. At the same time Sterry Hunt considers that, although there is a distinction between open veins and geodes formed in cavities, the contents, whether in granitic rocks or fossiliferous limestones, are not sensibly affected thereby. Such veinstones must consequently be looked upon as a kind of extract of the rocks, due to hydrothermal action, the many varieties resulting from the changing composition of the waters which circulate in the fissures, or are diffused through the rock itself.

It should be observed that in the Laurentians, the metalliferous veins carrying galena, blende, pyrites, and chalcopyrite are more recent than the veinstones just noticed, as the former cut the Potsdam sandstone, etc., whilst the latter group of veins are old enough for the Potsdam sandstone to rest upon their eroded outcrops. This fact may have an important bearing upon the origin of metalliferous deposits; a subject discussed, in the next essay, before a general audience at New York, where he declared that, what the alchemists sought for in vain—viz. the universal menstruum, is neither more nor less than water aided by heat, pressure, and the presence of certain substances. The metals, he had previously stated, seem to have been originally brought to the surface in watery solutions, were afterwards separated and reduced as sulphides, and mingled with contemporaneous sediments, and were during subsequent metamorphism redeposited in fissures in the metalliferous strata, or ascending to higher beds gave rise to metalliferous veins in other strata. He rejects the notion of intense heat, sublimation, and similar hypotheses. This theory may be a good one, but some of the arguments adduced in support of it will hardly bear examination. Speaking of the solubility (p. 231) of the salts and oxides of copper, lead, and silver, he asks why they do not accumulate in the sea-water like the salts of sodium. Most chemists would have thought that the sparing solubility of the chlorides of the two latter metals, especially of silver, was quite sufficient to account for the phenomenon; but when a chemist has at command the universal alkahest, he cares but little for a table of solubilities.

The most important paper in the collection is "The Geognosy of the Appalachians and the Origin of Crystalline Rocks" (xiii. p. 239), an address delivered on retiring from the office of President of the American Association for the Advancement of Science in 1871. Without following the author into the intricacies of Transatlantic geognosy, we must now consider Dr. Hunt in his capacity of geologist, merely remarking by the way that the references in this paper are necessarily of great value to those interested in American geology. At this time he viewed the Taconic system, as defined by Emmons, to constitute the true base of the Palæozoic column; but in the preface to the second edition he seems to draw an important distinction between the Upper Taconic and Taconian (see also GEOL. MAG. 1879, p. 519). It is of some importance to ascertain where he would draw this base-line, as immediately below come his four great groups of crystalline rocks, and it appears that we are threatened with other groups, "since it is by no means certain that the whole of the crystalline stratified rocks of New England are included in the above" (p. 281).

It would be unfair perhaps to dwell too much on the remarkable change of front exhibited by Dr. Sterry Hunt in his interpretation of the crystalline series above the Laurentians. We know that in 1861 he wrote that "the Green Mountain Gneissic formation, instead of being beneath the Silurian series, is really a portion of the Quebec group more or less metamorphosed, so that we recognize nothing in New England, or South-east Canada, lower than the Silurian system" (Can. Nat. vi. 93). In the two succeeding volumes he enlarges on this topic—the Montalban (now placed by Hitchcock below the Huronian) at that time figuring as metamorphosed strata of Upper Silurian and Devonian age. It is probable that Hunt at this period, with his usual impetuosity, was reflecting the views of others rather than recording his matured convictions, and it is singular, to say the least, that one holding the views on chemical geology which he seems then to have held could ever have given his adhesion to such a piece of epigenic metamorphism. And yet, as may be gathered from what he says with respect to the origin of granitic veinstones, and still more of metalliferous deposits, he is prepared to admit an amount of circulation, both greater and lesser, throughout the rocks, which, with the aid of the alkahest or universal menstruum, must be capable of producing not only molecular but metasomatic changes which shall meet all the requirements of the most advanced transmutationist. Dr. Hunt has written much and well, and his ample experiences as a geologist and a chemist entitle his opinions to respectful consideration. He may be a trifle hasty, and perhaps in the exigencies of the moment he is not always too particular. Thus he has been at issue with many writers and speakers, himself amongst the number; but we are bound to admit that in the interpretation of the crystalline series above the Laurentian his recantation is complete (p. 276), and he does not waste the time or abuse the patience of his audience by vain endeavours to maintain a reputation for infallibility.

The dates of Dr. Hunt's views are always of importance, and we find him stating in 1871 his conviction that the crystalline schists of Germany, Anglesey and the Scotch Highlands will be found anterior to the deposition of the Cambrian sediments. As is well known, he professes to be able to correlate by their lithological characters the schists of the British Isles with those on the other side of the Atlantic. The andalusite-schists in Donegal may be, as he states, of the type of the White Mountain series; but when he hints rather than affirms that the chiastolite schists of Skiddaw are to be referred to this group—placed by Hitchcock, be it remembered, below the Huronian—admiration gives place to incredulity; since the next step would be to claim the Skiddaw granite as Laurentian gneiss!

W. H. H.

II.—ON THE STRUCTURE AND AFFINITIES OF THE "TABULATE CORALS" OF THE PALÆOZOIC PERIOD. With Critical Descriptions of Illustrative Species. By H. ALLEYNE NICHOLSON, M.D., D.Sc., etc., Professor of Natural History in the University of St. Andrews. Illustrated with Engravings on Wood and fifteen Lithograph Plates. Super Royal 8vo. pp. 342. (London and Edinburgh, William Blackwood & Sons.)

IT might have been thought that the various memoirs on Fossil Corals which have been written by Edwards and Haime, Lindström, and other palæontologists, including Dr. Nicholson himself, would have pretty well exhausted all that could be said on the subject, and rendered a fresh work almost unnecessary; but a glance at the contents of this elaborate book at once shows that it is no mere recapitulation of what has already appeared in previous publications, but that it contains a great amount of additional knowledge respecting this division of Fossil Corals. This is not owing so much to the description of new forms, but rather to the results obtained by the examination of microscopic sections of forms already known. Whilst it is true that this method of investigation involves, in the preparation of thin transparent sections, a vast amount of preliminary work which only those who have undertaken a similar task are capable of estimating, there can be no doubt that it is only by this means that reliable evidence can be obtained and satisfactory conclusions drawn as to the true characters and affinities of these fossil organisms. Dr. Nicholson may be said to be the first to apply to any extent the microscopic method of investigation to elucidate the intimate structure of fossil corals; and the results which he has obtained serve to show in a striking manner the importance and necessity of microscopic examination in determining the intimate structure of corals. The great amount of material which the author has been collecting for many years past from those localities in Britain, the Continent of Europe and America, which have yielded most of the known fossil Tabulate Corals, has enabled him to carry out the task of a critical description of these forms with the great advantage of being able at will to compare and collate the specimens in his own cabinet.

Though this book treats of the Palæozoic *Tabulate* Corals, the author fully recognizes the necessity of abandoning this division as a natural group, and distributing the various families and genera included therein by Edwards and Haime amongst the other divisions of the Actinozoa. The presence of Tabulæ or horizontal diaphragms, which constituted the basis of the "Tabulata," has been shown by the researches of Louis Agassiz on the animal of *Millepora*, of Verrill on *Pocillopora*, and Moseley on *Millepora* and *Heliopora*, to be of very limited value as a main ground of classification, this structure appearing alike in organisms which undoubtedly belong to the Hydrozoa, Actinozoa, and Polyzoa. This fact of the existence of tabulæ in organisms so widely separated in the zoological scale has given rise to great differences of opinion as to the true affinities of the animals which constructed the numerous and varied tabulate corals of the Palæozoic rocks. Agassiz, basing his conclusions on the Hydrozoal nature of *Millepora*, would have relegated all the Tabulata to the Hydrozoa; but Verrill showed from the true Zoantharian character of the Tabulate *Pocillopora* that there was no ground for such a sweeping conclusion, and this opinion has been further justified by Moseley's discovery that the Tabulate *Heliopora* belongs also to the Actinozoa. The absence of a satisfactory basis for a determination of the true position of these fossils is sufficiently manifested, however, by the very varied positions to which different genera are assigned by the most eminent writers on this subject. One has only to consult the memoirs on Fossil Corals by Professor Martin Duncan, Dr. Lindström, M. Dollfus, Dr. Nicholson, Dr. Röminger, Professor Zittel, and others, to be convinced of the difficulty and uncertainty attending this subject. No small amount of this division of opinion probably arises from an incomplete knowledge of these fossils, and therefore the new facts respecting their minute structure which are recorded in the present treatise ought to have a great influence in reconciling opposite views.

Dr. Nicholson regards the old division of "Zoantharia Tabulata" of Edwards and Haime as comprising twelve distinct groups of animals, viz. Milleporidæ, Pocilloporidæ, Favositidæ, Columnariadæ, Syringoporidæ, Auloporidæ, Halysitidæ, Tetradiidæ, Thecidæ, Helioporidæ, Chætetidæ, and Labechidæ. Of these, all, except the first two families, are represented in the Palæozoic period.

The Milleporidæ and Pocilloporidæ being of comparatively recent origin, do not enter into the scope of this work; but the author fully accepts the Hydrozoal position of the first, and places the second in the Zoantharia Aporosa, associating therewith in the same family the recent genus *Seriatopora.*

The family of the Favositidæ, by far the largest and most important group of the "Tabulata," is referred to the order of the Zoantharia Perforata, and placed near the Poritidæ. No fewer than 22 genera are enumerated in this family, of which 20 are Palæozoic; one, *Koninckia,* is Cretaceous; and only one, *Favositipora,* Sav. Kent, of recent age. The great development of this family occurs in the Silurian and Devonian rocks, but few surviving into the Carboniferous, and perhaps but one, *Stenopora,* passing into the Permian. So important a part of the fauna of the Palæozoic age is constituted by the genera of this family, that it will be of interest to give a list of them:—

Favosites, Lam.
Alveolites, Lam.
Vermipora, Hall.
Michelinia, De Kon.
Pleurodictyum, Goldf.
Chonostegites, E. and H. (=*Haimeophyllum*, Bill.)
Pachypora, Linds.
Striatopora, Hall.
Trachypora, E. and H. (with *Dendropora*, Mich., and *Rhabdopora*, M'Coy.)
Cœnites, Eichw.
Columnopora, Nich.
Koninckia, E. and H.
Favositipora, Sav. Kent.
Aræopora, Nich. and Eth. jun.
Rœmeria, E. and H.
Syringolites, Hinde.
Nyctopora, Nich.
Römingeria, Nich.
Stenopora, Lonsdale.
Billingsia, De Kon.
Laceripora, Eichw.
Nodulipora, Lindström.

It would occupy too much space to follow the author in his exhaustive description of this and the other families, whose history, characters and relations are treated; all we can do is to refer briefly to a few salient points.

Dr. Nicholson includes in the genus *Favosites* the genera *Calamopora*, Goldf.; *Emmonsia*, E. and H.; and *Astrocerium*, Hall, all of which have been based on characters too variable to allow of generic distinction.

In the comparatively new genus *Pachypora*, Lind., 1873, of which the more distinguishing feature is the great thickening of the walls of the corallites by a deposition of sclerenchyma, is included a number of corals from the Silurian and Devonian of Europe and America, which had previously been referred to *Favosites*, *Alveolites*, and *Cladopora*, but have now been proved by microscopical examination to possess the peculiar characteristics of this genus. Microscopical sections have also determined the Favositoid character of the genera *Striatopora* and *Trachypora*; in this latter genus the secondary deposit of sclerenchyma in the corallites exists to such an extent that it had previously been believed to be provided with a dense cœnenchymal structure surrounding the somewhat widely separated apertures of the corallites. The genus *Cœnites*, with its peculiarly elongated calices, is also allied to *Pachypora*, and possesses a similar thickening of the corallite walls.

As respects the confusing genus *Alveolites*, the author concludes that the presence of septal teeth as a generic distinction will have to be abandoned, and that the only difference between this genus and *Favosites* is in the possession, in *Alveolites*, of oblique calices, and the compressed or triangular forms of the corallites.

The genus *Pleurodictyum*, Goldf., formed for the peculiar fossil *P. problematicum*, Goldf., so long a puzzle to palæontologists, is still retained as distinct from *Michelinia*. In a form belonging to the same genus from the Devonian of North America, Dr. Nicholson has detected the presence of the peculiar vermiform tube which appears to be constantly associated with *P. problematicum*, but he is unable to throw any fresh light on its probable character.

The genus *Stenopora*, Lonsdale, is shown to belong to the Favositidæ, and to possess very distinctly marked characters, in the corallites being annulated by periodical ring-shaped thickenings. The position of the genus *Rœmeria*, E. and H., is regarded as uncertain, as it has not been proved to possess mural pores; *Syringolites*, Hinde, appears to form a connecting link between the Favositidæ and the Syringoporidæ, and *Nyctopora*, Nicholson, seems to be intermediate between the Favositidæ and the Columnariadæ, as it possesses all the characteristics of this latter family except in having mural pores.

We pass now to the next family of the Columnariadæ, which has been constituted by the author to include a small group, principally of American Silurian corals, distinguished by the non-perforate walls of the corallites, well-marked tabulæ, and well-developed septa. The family seems to be closely allied to the Rugosa, whilst it has also resemblances to the Astræidæ of the Zoantharia Aporosa. With the genus *Columnaria*, Goldf. (= *Favistella*, Hall), is also associated, to form this family, the genus *Lyopora*, Nich. and Eth. jun.

The family Syringoporidæ is looked upon as an aberrant group of the Zoantharia Perforata, having genuine but distinct relations with the Favositidæ. The author regards the hollow processes connecting the corallites, which distinguish this family, as homologues of the mural pores of *Favosites*, corresponding with the hollow transverse floors connecting the corallites in *Chonostegites Clappi*, Edw. and H.; whilst in the central tube of another Favosite genus, *Syringolites*, Hinde, there is a close similarity to the infundibular tabulæ of *Syringopora*.

Our present knowledge of the family Auloporidæ is insufficient to determine its true relationship, though the author conjectures that it may be a peculiar group of Alcyonaria. It includes the genera *Aulopora*, Goldf., *Cladochonus*, M'Coy (= *Pyrgia*, Edw. and H.), and *Monilopora*, Nich. and Eth. jun.

The family of the Halysitidæ is formed for the single well-known genus *Halysites*, Fischer, and regarded as a distinct and ancient group of the Alcyonaria. *Halysites catenularia*, Linn., is shown to possess intermediate smaller tubes, indicating the existence of two classes of zooids, as in *Heliopora*; but in the otherwise closely resembling *H. Escharoides*, Lam., there are only uniform corallites, in which, however, spiniform septa are constantly present and disposed in cycles of twelve. If these septa bear any relation to the number of mesenteries in the living animal, it is difficult to see how *Halysites* can be regarded as an Alcyonarian, this group having only eight mesenteries.

The family of the Thecidæ comprises merely the single genus *Thecia,* Edw. and H., with very peculiar characters, now, for the first time, made known from microscopic sections. There are two kinds of corallites; the larger, though well defined, have no distinctive bounding walls, and the interspaces between these are occupied by very small tubular corallites, doubtfully tabulate, but with well-defined walls. There are also horizontal canals connecting the larger corallites. The family is regarded as a special group of the Alcyonaria.

The important family of the Helioporidæ mostly comprises the Palæozoic genera *Heliolites,* Dana, *Plasmopora,* Edw. and H., *Propora,* Edw. and H., *Pinacopora,* Nich. and Eth. jun., and *Lyellia,* Edw. and H.; the Cretaceous genus *Polytremacis,* D'Orb., and the recent *Heliopora,* De Blain. These various genera are included in this family from the supposed correspondence of their fossil structures with the corallum of the existing *Heliopora,* the animal of which has been proved by the researches of Mr. Moseley to be a true Alcyonarian Zoophyte, furnished with eight mesenteries, and eight pinnately-fringed tentacles. It appears to us, however, that there are considerable differences between the corallum of *Heliolites* and its allied Palæozoic forms, and the recent *Heliopora cœrulea,* sufficient to throw considerable doubt as to the propriety of associating them in a single family of Alcyonaria. We regret that Dr. Nicholson has not subjected the modern corallum of *Heliopora* to the same critical examination which he has bestowed on the Palæozoic *Heliolites,* before accepting the classification of Mr. Moseley, and we will venture to point out what appear to us some of the points of difference. In the first place, the larger corallites or calicles of *Heliopora cœrulea* do not appear, from Mr. Moseley's account, to possess any distinctive proper wall. He says:[1] "New calicles are formed by the junction of a number of tubes around a central tube or tubes arrested in growth, which form a base. The outer walls only of the surrounding tubes continue to grow, and form the lateral wall of the calicle. The newly-formed calicle thus has tabular prolongations at its base, and the so-called septa are, in the main, due to the circumstance that *the wall is composed of a series of curved outer walls of tubes.*" Our own observations of *H. cœrulea* fully confirm the correctness of the above description. Now, so far as we are acquainted with *Heliolites* and its allied Palæozoic genera which have been placed with *Heliopora,* there is not a single species in which the tubes of the larger corallites are formed in a similar manner to those of *Heliopora,* but in all there is a distinct proper wall to the larger corallites. Again, with regard to the septa of *Heliopora,* these, according to Moseley, are in the main due to the curved outer

[1] We quote from the Report given in the Ann. and Mag. of Nat. History, Feb. 1876, p. 147, *et. seq.*, "On the Structure and Relation of certain Corals, etc.," by H. N. Moseley, M.A., F.R.S.

walls of the tubes bounding the calicles, and therefore cannot be compared with the regular normal septa which are met with in *Heliolites*, and which in some instances extend nearly to the centre of the corallite. The pseudo-nature of the septa of *Heliopora* sufficiently explains the absence of all correspondence between their *variable* numbers and the number of the mesenteries; but it is highly probable that the septa of *Heliolites* indicate a similar number of mesenteries in the living animal; and as there are pretty constantly twelve septa, it follows that the animal could not have been Alcyonarian. There is no doubt that *Heliolites* and some of its allied forms possessed two kinds of zooids, the same as *Heliopora;* but a corallum of larger and smaller tubes indicating this, is also found in the Monticuliporidæ, Halysitidæ, and not improbably in some of the Favositidæ, whilst it is very doubtful whether the genus *Lyellia*, Edw. and H., here placed with *Heliopora* and *Heliolites*, actually possessed smaller incomplete zooids ; for the intermediate structure between the larger corallites, instead of being tubular, is distinctly vesicular—the larger corallites themselves closely resemble those of a typical *Heliolites.* We therefore think that the evidence is insufficient to conclude that *Heliolites* and the allied Palæozoic genera above named are truly Alcyonarian the same as *Heliopora.*

Two chapters, the twelfth and thirteenth, are devoted to a consideration of the families of the Chætetidæ and Monticuliporidæ, and the author believes that he has discovered satisfactory grounds of division between these very confusing groups. To the Chætetidæ are referred corals with uniform corallites, having the walls completely amalgamated, and but few and remote tabulæ, whilst the Monticuliporidæ are distinguished by corallites of different sizes indicating the existence of two kinds of zooids; their walls are not fused with each other, and the tabulæ are well developed. The author rejects the idea which has been proposed to place these families with the Polyzoa, though it is very probable that many of the incrusting forms probably belong to this higher group of animals, and is disposed to regard them as a special group of Alcyonaria.

In the final chapter the family Labechidæ is treated, and the characters of the very aberrant genus *Labechia* are described. The absence of all apertures on the surface of the corallum of this form and the peculiar projecting solid calcareous rods render it so different from all other groups of corals, that its relations must for the present remain a matter of conjecture.

In concluding our notice of this work we desire to express our admiration, not only at the unwearied industry of the author in bringing together such an amount of research into the characters and relations of these ancient corals, but also at the very excellent manner in which the treatise is published. In addition to the woodcuts in the text, there are fifteen beautifully executed lithographed plates, mostly illustrating microscopic sections, and the drawings for these have been made by Dr. Nicholson himself. Whatever future discoveries may disclose as to the affinities of these corals, this work will always retain a permanent value for its minute and faithful description of these organic remains, and all students of Palæontology will be indebted to Dr. Nicholson for thus bringing together in a single volume the history of this important division. We can only express the hope that what the author has here accomplished for the old order of the Tabulata, he may be induced to undertake for the other orders of the Palæozoic corals.

III.—A Manual of Palæontology for the Use of Students, with a General Introduction on the Principles of Palæontology. By Henry Alleyne Nicholson, M.D., D.Sc., Ph.D., F.R.S.E., F.G.S.; Professor of Natural History in the University of St. Andrews. 2nd Edition. Revised and greatly enlarged. In two vols. Royal 8vo. pp. 1070, with 722 Woodcut Illustrations. (Edinburgh and London: William Blackwood & Sons, 1879.)

THOSE who, like the writer, can carry back their intimate acquaintance with geological events for more than a quarter of a century, cannot fail to be astonished at the change which has arisen in the literature connected with their special branch of study, and particularly that which relates to text-books and works for the use of students. In 1855, "Lyell's Elements" had already attained its 5th edition; it was *the book*, and almost *the only book*, for the learner. Previously Mantell's works, Buckland's Bridgewater Treatise, and Conybeare and Phillips, were the only really good sound books to consult; now there are more than a dozen authors ready to impart to us out of their stores of geological and palæontological knowledge, things old and things new.

Happy is that student who obtains the aid of a really sound geological Mentor, one who is able to guide his steps in safety amidst Glacial epochs, Volcanic eruptions, Pluvial periods, Eozoonal Limestones, Evolutionary ancestral forms, and Quaternary deposits, into the haven of Truth.

Not only have our teachers vastly multiplied, but our subject of study has divided itself, so that, like a complex system of railway lines, one may travel on the Physiographical branch, or the Geographical one, on the Stratigraphical, the Petrological or the Palæontological—and may be, and we trust are, all moving *forward*, but on quite different roads, so extensive has our subject become in the last twenty-five years.

Formerly a geologist was also a mineralogist, and a palæontologist; now a man may be a geologist without knowing either of these subjects; or he may be a crystallographer, a petrologist, a mathematician, or a chemist, and yet not a mineralogist; or, a palæontologist, or zoologist, and yet not a geologist!

Certainly the more one studies the relics of bygone ages in the light of forms of life still existing on our planet, the more we are able rightly to understand "The Ancient Life History of the Earth."

Prof. H. Alleyne Nicholson, the writer of the Manual of Palæontology now before us, is peculiarly fitted for the task he has set himself to perform. He is not only a sound practical geologist, but he is also an excellent zoologist and palæontologist; added to which, he has had more than ten years' experience as a teacher of students, and has thus been brought face to face with the needs of his class. Neither is Prof. Nicholson a mere "prentice-hand" at the writing of Text-books. Already he stands credited with :—

1. "A Manual of Zoology."
2. "A Text-Book of Zoology."
3. "An Introductory Text-Book of Zoology."
4. "Outlines of Natural History for Beginners."
5. "Examinations in Natural History."
6. "Introduction to the Study of Biology."
7. "The Ancient Life-History of the Earth;" and
8. "A Manual of Palæontology" (already in its 2nd edition).

The first edition of Nicholson's Manual of Palæontology, which appeared in 1872, was contained in a single volume of moderate 8vo. size, numbering 600 pages, with 400 woodcuts. The present edition occupies two handsome 8vo. volumes, consisting of 1070 pp., with 722 woodcuts, and is so largely re-written and augmented, that it forms to a great extent a new work.

The First Part (embracing 6 chapters and 94 pp.) is devoted to a General Introduction to Palæontology in connexion with Stratigraphical Geology.

From this we are led on in Part II. (Palæontology) to consider group by group the several divisions of the great Invertebrate subkingdom from the Protozoa to the Lamellibranchiata, their general characters and their distribution in time, and the literature of each division. This occupies 17 chapters and 417 pp., and lands us at the end of vol. i.

The Invertebrata extend through the first 100 pp. of vol. ii. including the Gasteropoda and Cephalopoda, and with chapter xxix. commences the Vertebrata—treated much in the same fashion, giving to each order its distribution in time as well as its general characters. This portion of the work occupies 20 chapters and pp. 326.

Part III. is divided into four chapters on Palæobotany, and fills 50 pages, treated very briefly, but in a similar manner to the previous divisions.

The volume ends with a Glossary and Index.

One important feature of the work is its illustrations, more than 700 in number, which are very excellent; a few (as invariably happens in so large a work) had better, however, have been omitted —as, for example, fig. 212, labelled *Illænus Barriensis,* and the singularly crafty-looking, but decidedly stuffed, *Myrmecobius fasciatus* (fig. 600).

Hundreds of the figures are of the highest merit as wood engravings, and many appear for the first time, being engraved expressly for this work by Mr. Charles Berjeau.

Each Order has its diagnostic characters printed in italics at the commencement of its own chapter; and at the end of each will be found a copious list of references to works and authorities who have specially treated upon the group just summarized.

In passing rapidly over the pages, we notice that *Eozoon Canadense* still holds its place among Foraminifera; the researches of Dr. Mobius not having reached the author in time to become available for incorporation. Sufficient, however, is said concerning MM. Carter's, and King's, and Rowney's investigations, to render its organic nature at least doubtful.

Under Mollusca (vol. ii. p. 14) a curious error is retained from the first edition—viz. that "the small cowries, of which *Cypræa Europæa* is the type, are not known as occurring in the fossil condition."

There are thirteen species of *Cypræa* given in Morris's catalogue, including *Cypræa Europæa* from the Suffolk Crag.

The Coniferous trunk (vol. ii. p. 448, fig. 701), from the Lower Devonian, Gaspé, Canada, named by Dawson *Prototaxites Logani*, and referred by him to the *Taxineæ*; was shown by Mr. Carruthers (in 1872) to be only a Cellular Cryptogam, and was renamed by him as *Nematophycus Logani*, Carr. (Monthly Microscopical Journ., vol. viii. Oct. 1872, pp. 160–172, pl. 31 and 32; see also Geol. Mag. 1873, Vol. X. p. 462).

Like every large text-book, however, it is easy enough to take exception to special points in the work, and whilst regretting the year's delay which has occurred in its issue (see Preface), which makes it seem, in parts, perhaps, a little in need of more rigid posting up, it is certainly the best book of its kind for the use of students, and for the general reader, which we possess. In saying this, it is well to recall the fact that "Owen's Palæontology" (A. & C. Black) appeared as early as 1860, and the 2nd edition in 1861; and although now rather out of date, we are indebted to Professor Owen, and to the late Dr. S. P. Woodward (author of the Invertebrate portion of the work), for the first issue of a Manual specially devoted to Palæontology in this country; a work which may (to use Prof. Owen's own term) perhaps have served as the "Archetype" to the author of the present work.

We trust that Nicholson's Manual of Palæontology will have the success it merits, and shall look forward with confidence to succeeding editions still more complete than even the present volumes.

REPORTS AND PROCEEDINGS.

I.—Chester Society of Natural Science.—Annual Conversazione.—The Annual gathering of this flourishing provincial Society took place on Thursday, 2nd October, 1879, under the presidency of Prof. T. McKenny Hughes, M.A., F.G.S. On this occasion the "Kingsley Memorial Medal," established in memory of the Society's first President, Canon Kingsley, was awarded to Sir Philip de Malpas Grey-Egerton, Bart., M.P., F.R.S., etc., for "having contributed materially to the promotion and advancement of natural science." In presenting the Medal, Prof. Hughes referred to the splendid work which Sir Philip Grey-Egerton had achieved in his researches on Fossil Fishes, in which branch of study he was now universally recognized as the foremost man among all his contemporaries. The President also alluded to his valuable services in Parliament for well-nigh fifty years—but most of all as the representative man of science; and in this his highest capacity he asked Sir Philip Egerton to accept the Kingsley Memorial Medal.

Sir Philip Grey-Egerton in reply thanked the President and Committee of the Society for having awarded that medal (founded to perpetuate the memory of the late Canon Kingsley) to him. He wished he could be inspired with the fervid eloquence which flowed from the lips of him whose likeness was so faithfully portrayed on that medal, and whose burning words found their way into the hearts of all his audience, not only in Chester, but throughout the United Kingdom. He should look back to this presentation as one of the happiest events in his life, as connecting his name with that of his late friend, Canon Kingsley; and he thanked his friends in Chester who had wished thus to associate him with the founder of their Society. He trusted the flame which Canon Kingsley had kindled would never be darkened, but extend its genial light further and further, illuminating with its brilliancy all who might be fortunate to come within reach of its radiance.

II.—Geological Society of London.—November 5, 1879.—Henry Clifton Sorby, Esq., F.R.S., President, in the Chair.

The following communications were read:—

1. "On the probable Temperature of the Primordial Ocean of our Globe." By Robert Mallet, Esq., F.R.S., F.G.S.

According to the latest hypotheses as to the quantity of water on the globe, its pressure, if evenly distributed, would be equal to a barometric pressure of 204·74 atmospheres. Accordingly water, when first it began to condense on the surface of the globe, would condense at a much higher temperature than the present boiling-point, under ordinary circumstances. The first drops of water formed on the cooling surface of the globe may not impossibly have been at the temperature of molten iron. As the water was precipitated, condensation of the remaining vapour took place at a lower temperature. The primordial atmosphere would be more oblate and less penetrable by solar heat than the present, and the difference of temperature between polar and equatorial regions would be greater; so that, in the later geologic times, ice may have formed in the one, while the other was too hot for animal or vegetable life. Thus, formerly the ocean would be a more powerful disintegrant and solvent of rocks, mineral changes would be more rapid, and meteoric agencies would produce greater effects in a given time.

Replying to remarks from the President, Mr. John Evans, Prof. Prestwich, Dr. Hicks, Prof. Bonney, and Capt. Galton, Mr. Mallet said he did not suppose any part of the original crust of the globe remained at present visible at the surface. Such geological deductions as were made in his paper were only illustrative, and might be open to question. The epoch at which the phenomena occurred to which his paper referred was long anterior to the existence of either animal or vegetable life upon our globe. Hence the palæontological observations that had been made did not seem to him to apply. What he does affirm as certain is that the method he has indicated, requiring for its data a more extended experimental knowledge of the relations between temperature and pressure in aqueous vapour, and a more exact knowledge of the total volume of water now upon our terraqueous globe, affords the means of determining the temperature of our oceanic water at every period, from that of the primordial ocean to our own day.

2. "On the Fish-remains found in the Cannel Coal in the Middle Coal-measures of the West Riding of Yorkshire, with the description of some new Species." By James W. Davis, Esq., F.G.S., etc.

The remains described by the author were from a bed of Cannel Coal about 400 feet above the base of the Middle Coal-measures, and were chiefly obtained from this bed at the Tingley Colliery. The author described the general geological structure of the district. At Tingley the fish-remains were stated to occur in greatest abundance between the Cannel Coal and the "hubb"; but they are also found in both those portions of the deposit. Of known species the author has identified:—*Cœlacanthus lepturus, Ctenodus elegans, Megalichthys Hibberti, Rhizodopsis*, sp., *Palæoniscus*, sp., *Gyracanthus formosus, Ctenacanthus horridus, Diplodus gibbosus, Ctenoptychius pectinatus, Helodus simplex,* teeth of *Cladodus* and *Petalodus*, scales of *Rhizodus*, ribs and bones of *Ctenodus, Pleuracanthus lævissimus*, and six other species, and the following which are described as new forms:—(1) *Compsacanthus triangularis*, (2) *C. major*, and (3) *Ostracocanthus dilatatus*, the type of a new genus resembling *Byssacanthus*, Agass. The teeth of *Cœlacanthus* were said to be small and sharply pointed; they have not been found attached to the jaw, but in certain specimens of the latter the alveolar spaces are well shown, extending in a single row along the rami. The air-bladder of this genus is also said to be preserved, and to present some resemblance to the bony air-bladders of Siluroid fish inhabiting the fresh waters of Northern India; and in general the author dwelt at considerable length upon the possible relationships existing between the fishes whose remains he described and the Teleostean Siluroids and *Ostracion*.

3. "On the Skull of *Argillornis longipennis*, Owen." By Prof. R. Owen, C.B., F.R.S., F.G.S., etc.

In this paper the author described a fragmentary cranium from the London Clay of Sheppey, from which it was procured by W. H. Shrubsole, Esq., who also furnished him with the humerus described in a former paper under the name of *Argillornis longipennis*.[1] In the present specimen the lower jaw and the fore part of the upper jaw are deficient. The author described the characters presented by the specimen in detail, and stated that, like those of the humerus previously described, they seemed to approximate the fossil most nearly to the Albatross among existing birds, although, like *Odontopteryx*, it differed from *Diomedea* and also from the Cormorant and the Totipalmates generally, in the absence of the basirostral external nares and of the supraorbital gland-pits. The present fossil differs from *Odon-*

[1] Quart. Journ. Geol. Soc. vol. xxxiv. p. 124.

topteryx in having the fore part of the frontal broader and the upper tract of the bill less defined, as also in some other characters; but no comparison of the palatal structure can be made upon the existing specimens. In point of size, taking the Albatross as a term of comparison, this skull may well have belonged to a bird with wings of the extent indicated by the humerus already described; and the resemblance of the skull to that of the Albatross would also seem to be confirmatory of the specific collocation of the two specimens. The presence of four small pits or perforations on the only part of the alveolar border which appears to be uninjured, leads the author to conjecture that the bird may have been dentigerous.

III.—Cambridge Philosophical Society.—Monday, Nov. 10.—Prof. Newton, M.A., F.R.S., President, in the chair.

The President alluded to the great loss sustained by Science in general, and by the Society in particular, by the death of Professor Clerk Maxwell, who had so recently occupied the position of President. He considered it a great privilege to be able to give expression to the deep and sincere sorrow that every member of the University felt in the death of so distinguished a member as Professor Maxwell.

The following communication was made to the Society:—

"On implement-bearing loams in Suffolk," by Mr. O. Fisher. The author gave an account of two visits paid to the district in which Mr. Skertchly of the Geological Survey has lately discovered flints worked by man, in loams described by him as interglacial. The first of these visits was made in 1876, and the country examined lay chiefly to the north-east of Brandon. The author was not convinced by anything which he then saw of the correctness of Mr. Skertchly's views. But since he saw only a portion of the district which that gentleman had examined, the data were necessarily incomplete. The second visit was made by him at the end of September last, and he then saw sections in the neighbourhood of Mildenhall and Bury St. Edmund's, which convinced him of the truth of Mr. Skertchly's announcement of the occurrence of the loams in question with their implements beneath massive Boulder Clay *in situ*. At the brickyard at Culford, near Bury, in particular, the section is unmistakeably clear. Fifteen feet of the ordinary Chalky Boulder Clay, a spur of the great mass which spreads over a large part of the county, is seen covering the stratified loam, and from the loam at this place Mr. Skertchly extracted with his own hands a worked flint which he exhibited to the Society at the reading of the paper. The author did not himself see the Boulder Clay lying beneath these loams at the places where they had yielded implements. He was, however, assured by Mr. Skertchly that when some of the sections were better exposed, this was evidently the case. The loam in question has the appearance of being a fluviatile deposit, and at one place freshwater shells occur in it; it evidently occurs over a considerable district.

A discussion took place, in which Mr. Skertchly, Professor Hughes, Dr. Campion, and Mr. E. Hill, took part.

CORRESPONDENCE.

THE AGE OF THE PENNINE CHAIN.

Sir,—The Number of the Geological Magazine for November contains a very thoughtful paper by Mr. Wilson, F.G.S., on the age of the upheaval of the Pennine Chain or "Backbone of England," in which he controverts my views regarding the precise epoch of primary upheaval, and comes to the conclusion that it was Pre-Permian, instead of Post-Permian and Pre-Triassic; the conclusion I had previously arrived at. He has very fairly stated my arguments and his objections to them. With the time at my disposal, it would be impossible for me to recall all the facts and inferences which were vividly impressed on my mind at the time I wrote the paper on this subject to which Mr. Wilson refers.[1]

The arguments are there, and every one must judge for himself whether they are conclusive or not. I admit the force of Mr. Wilson's inference, that there must have been *some* westerly uptilting of the beds of the Yorkshire Coal-field before the Permian period, from the well-known fact that the Coal-measures dip at a slightly greater inclination towards the east than does the Magnesian Limestone which overlies them. This dip is, however, but slight, because it only amounts to the difference between the inclination of the two formations; and I suppose 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.

The principal objection to Mr. Wilson's reasoning seems to lie in his statement that the Permian beds on either side of the Pennine axis were originally disconnected, and on this he bases one of his arguments for supposing the existence of the disconnecting Carboniferous ridge during the Permian period. To this view I entirely dissent, on grounds which I have stated at some length in a paper which Mr. Wilson seems to have overlooked, and perhaps with some reason, considering its title.[2] In that paper, I call attention to the remarkable resemblance between the Permian formation as it occurs in Lancashire, and the same formation as it occurs in Yorkshire and Durham, which strongly impressed me with the conviction that there could have been no intervening barrier between the two areas. Mr. Binney, and, still later, Mr. Kirkby, have shown that the fossils of both districts are truly representative of each other, and deposited in the same general basin, although under somewhat different conditions—the Upper Permian beds of Lancashire having been formed in shallower waters and in a sea somewhat clouded by muddy sediment. Though quoted by Mr. Wilson as one of the authorities for the statement that "there is no similarity

[1] Quart Journ. Geol. Soc. vol. xxiv. p. 323 (1868).

[2] "On the Evidences of a Ridge of Lower Carboniferous Rocks under the Plain of Cheshire, etc.," Quart. Journ. Geol. Soc. vol. xxv. p. 171.

either in character, thickness, or succession of the Permians on the opposite side of the Pennine Chain," I quite dissent from his way of putting my views, except in the matter of "thickness," which is of very little importance in an inquiry of this kind. On the contrary—both in Yorkshire and Lancashire—we have Upper Permian beds represented by Magnesian Limestones with identical fossils, and Lower Permian beds, consisting of soft sandstone of very great thickness at Stockport and elsewhere, close to the edge of the Pennine Chain.

I cannot consent "to omit from consideration" the "Lower Permian Sandstone" as Mr. Wilson wishes us to, on the ground that "its true horizon seems doubtful." There is really no such doubt, as, both at Manchester and Stockport, these sandstones have been proved to rest unconformably on the Coal-measures on the one hand, and be overlain by marls with limestone containing Permian fossils on the other. Then, again, both of these formations are unconformably overlain by the New Red Sandstone, as was clearly proved by the borings at Heaton Mersey, below Stockport, and other places. I must repeat, therefore, that there can be no question that the Lower Red Sandstone of Stockport is the representative of the Lower Red Sandstone of Durham and North Yorkshire; for they agree both in position, character, and their relations to the adjoining formations—both above and below.

If this be so, I would ask Mr. Wilson how can he account for the fact that this Lower Permian Sandstone is remarkably free from fragments of Carboniferous rocks, or, indeed, of rocks of any kind, if it was deposited at the base of a Carboniferous ridge?

As I have already shown, in the paper just quoted, the differences in the characters of the Permian rocks in the N.W. and N.E. of England are those of degree rather than of kind, and may be accounted for on the law, or principle, which will be found to characterize many natural groups or formations; namely, the development, in opposite directions, of calcareous and sedimentary strata.[1] The real Carboniferous barrier of this period lay below the Cheshire Plain, reaching the Carboniferous tract along the valley of the Dane, near Bosley. To the north and south of this ridge the Permian beds were connected more or less across the country.

In conclusion, I cannot admit that the absence of such a thin and local formation as the Marl-slate of the North-east of England in Lancashire or Cumberland is of much importance in this inquiry. I can point, on the other hand, to real Magnesian Limestones at Skillaw Clough, and two or three other spots, as evidences of connexion between the east and west. I do not therefore see sufficient reason for altering the conclusion to which I have already arrived, while I admit that both points of view—that held by Mr. Wilson, and by myself—have their difficulties.

EDWARD HULL.

[1] *Ibid*, p. 176.

FOSSILS ON CLEAVAGE PLANES.

Sir,—The Rev. W. Downes, who has done good service among the Limestones of Westleigh and Holcombe Rogus, in Devonshire, has in a second paper on this subject [Trans. Devon Assoc. 1879] brought forward the question, "Is it absolutely a universal rule that fossils do never occur otherwise than on a plane of bedding?" He notices his discovery of organic remains, referred by Prof. T. R. Jones to *Posidonomya*, on a surface of rock which is unquestionably a cleavage plane. Among his specimens from Westleigh is a *Spirifer* manifestly imbedded in a vertical position, while upon the same piece of rock a *Chonetes* and a *Posidonomya* are lying upon the plane of bedding. He suggests, that the planes of separation will be determined by the lines of least cohesion, and that the presence of a flattish fossil, approximately parallel to the lines on which the cleavage force was acting, would be apt to create a plane of weak cohesion on which the external pressure would most readily take effect. We should have been disposed to think that the position in which the fossil was imbedded accidentally coincided with the cleavage plane, and it was therefore saved from distortion. Mr. Downes however remarks that the cleavage is of an irregular kind; seeming often to result from the folds of the hard limestone rocks crushing the intervening shaly beds. The subject is one well worthy of attention. H. B. Woodward.

RIPON SWALLOW-HOLES.

Sir,—The Rev. J. S. Tute of Markington, near Ripon, has a notice of these "natural pits" in Vol. V. Geol. Mag. page 178. That the denuding agencies employed in producing them are no more dormant now, than formerly, is certain. The latest subsidence occurred in '77, in the West Field, near Hutton Conyers. This field is pitted over with holes of more ancient date, and there also, cylindrical-shaped holes, locally known as "man-holes," appear at intervals. When first found, they are seen to contain water, which soon disappears. To prevent animals falling in, they are filled up as quickly as possible. A "man-hole" that has been closed, after a time, becomes again an open shaft, when the material with which it had been filled is found to have been "swallowed." The subsidence of '77 is a hole of very considerable dimensions, in shape an inverted cone, the walls being thick-bedded red sandstone. It is fenced round. About one hundred yards from it, and abutting on the footpath leading from the village to Ripon, there is a shallow basin-shaped depression in the surface of the soil. This place has been watched for a number of years by a gentleman residing in the village,[2] who finds it sinks four or five inches in a year.

The "man-holes" are said to occur, mostly, during very wet seasons, and some of the farmers think after sheep have cleared the land of turnips. A. G. Cameron,

Northallerton, *Nov.* 1879. H.M. Geol. Survey.

[1] Also a full account in a paper read at Ripon, before York. Geol. Society, in 1869.
[2] Mr. Thomas Wells, of Hutton Conyers.

ON THE STRUCTURE AND AFFINITIES OF THE PLATYSOMIDÆ.

SIR,—I am very sorry to find that my esteemed friend, Professor H. Alleyne Nicholson, has in the new edition of his "Manual of Palæontology" (vol. ii. p. 138, *footnote*) committed the mistake of quoting me as his authority for elevating the Platysomid fishes to the "rank of a distinct division of Ganoids." No such proposition occurs in the unpublished paper to which he refers, which was written to follow up the views indicated in my account of the structure of the Palæoniscidæ (Pal. Soc. Mon. 1877) regarding the abolition of the suborder "Lepidopleuridæ," necessitated by the demonstration of the fact that the Platysomidæ, as a family, are not really allied to the Pycnodontidæ, but are on the other hand so closely linked to the Palæoniscidæ, by ties of structure, that wherever we place the latter family, thither the Platysomidæ must follow.

My paper on the "Structure and Affinities of the Platysomidæ" was read before the Royal Society of Edinburgh on May 5, of this year, and will in a few weeks appear in the forthcoming fasciculus of that Society's Transactions. Prof. Nicholson's mistake has obviously arisen from his having had only a very hurried glance over my proof-sheets, and that only on a single occasion. R. H. TRAQUAIR.

8, DEAN PARK CRESCENT, EDINBURGH,
12*th Nov.* 1879.

MISCELLANEOUS.

WE are glad to notice that Mr. G. A. Lebour, F.G.S., Lecturer in Geological Surveying in the University of Durham College of Physical Science, Newcastle-on-Tyne, has in preparation a Nomenclator Stratigraphicus, or Handbook of the Nomenclature of the Sedimentary Rocks. This work, which has been in hand for several years, consists of a list—as complete as may be—of the subdivisions of the Geological Scale now, or at any time, in use in this country or abroad. The names are arranged in alphabetical order as the easiest for reference. In every possible case the author responsible for each name is mentioned. The date of publication, the meaning when it seems necessary, and the equivalence, are also given. The volume will be of at least 250 pp., and will be published as soon as the number of subscribers has reached two hundred. Price to subscribers 7*s*. 6*d*. Subscribers' names and subscriptions may be sent to Mr. G. A. Lebour, 2, Woodhouse Terrace, Gateshead-on-Tyne.

OBITUARY.

WE regret to learn the death of Mr. John King of Thorpe Hamlet, Norwich, whose extensive collection of fossils from the Upper Chalk of the country around Norwich was at all times open to students. So long ago as 1833 Mr. King's collection was noticed as a large one, containing many rare specimens (S. Woodward, Geology of Norfolk, p. 32). These ultimately included a fine series of Echinoderms, Mollusks, Sponges, etc.; and numerous flints cut and polished to show organic and inorganic structure. Mr. King was the surviving partner of the well-known firm J. & J. King, Stained Glass Painters, etc., of Norwich. He died on October 19, aged 72 years.—H. B. W.

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