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EDITED BY

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

VICE-PRESIDENT OF THE GEOLOGISTS ASSOCIATION;

MEMBER OF THE AMERICAN PHILOSOPHICAL SOCIETY, PHILADELPHIA; HONORARY MEMBER OF THE YORKSHIRE PHILOSOPHICAL SOCIETY; OF THE GEOLOGICAL SOCIETIES OF EDINBURGH, GLASGOW, AND NORWICH; CORRESPONDING MEMBER OF THE GEOLOGICAL SOCIETY OF BELGIUM; OF THE NATURAL HISTORY SOCIETY OF MONTREAL; AND OF THE LYCEUM OF NATURAL HISTORY, NEW YORK.

ASSISTED BY

PROFESSOR JOHN MORRIS, M.A., F.G.S., &c., &c.,

AND

ROBERT ETHERIDGE, F.R.S. L. & E., F.G.S., &c.

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## LIST OF PLATES.

## LIST OF WOODCUTS.

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# GEOLOGICAL MAGAZINE.

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No. I.—JANUARY, 1878.

## ORIGINAL ARTICLES.

### I.—Recent Progress in Palæontology.

Being the Inaugural Address delivered before the Edinburgh Geological Society at its 44th Anniversary Meeting on the 27th November, 1877.

By H. Alleyne Nicholson, M.D., D.Sc., F.R.S.E.;
Professor of Natural History in the University of St. Andrews, and Swiney Lecturer on Geology.

SINCE its foundation as a Science, at the beginning of this century, by the illustrious Cuvier, Palæontology has progressed with an astonishing rapidity; and though theoretically belonging to the twin sciences of Zoology and Botany, its domain is now so vast, and the number of facts which it has accumulated is so great, that it has every claim to rank as a distinct department of knowledge, which cannot be fully mastered except by those who make it the subject of special study. That the number of these is daily increasing is shown conclusively by the increased number of systematic works on Palæontology which have appeared of late years, and not less by the character of these. Two of these treatises, both as yet but partially published, may be singled out for mention in this connexion—namely, the "Handbuch der Palæontologie" by Professors Zittel and Schimper, and the new "Lethæa Geognostica" by an association of German palæontologists. The former of these, if carried out with the fulness and accuracy which distinguish its first portion, will be one of the most valuable and important treatises on systematic palæontology which we possess in any language, and will be a fitting companion to the classical treatises of Pictet and D'Orbigny, though it will not supersede either of these honoured works. Of the second of these only the first part, embracing the Atlas of Plates of Palæozoic fossils, has as yet been issued; but if the text be equal to the plates, and if the various sections of the work are undertaken by men as eminent as Ferdinand Roemer, the new "Lethæa Geognostica" will undoubtedly form an indispensable item in the library of every working palæontologist.

If it be the Germans whom the student has to thank for these new systematic treatises, it is to the English-speaking races that we owe the latest attempts to reduce the present chaotic condition of palæontology to order, by establishing a bibliography of the science, and by the preparation of catalogues of the fossils of particular formations or of particular countries. In carrying out the first of these ends, the successful foundation of the "Geological Record" must be regarded as a great step in advance. In this invaluable, but necessarily dry, publication the student will find the titles of all works and papers on geological or palæontological subjects published during the current year throughout the world, together with, in most cases, a short summary of their contents. The value of such a record of contemporaneous work can hardly be overestimated. But in order to bring this subject to ideal perfection, it will be necessary that there should be prepared for each country a complete bibliographical and descriptive catalogue of all works and memoirs dealing with its palæontology, which have been at any time published. As regards the Invertebrate Palæontology of the North American Continent, such a "Bibliographical Report" is now in process of preparation by Prof. C. A. White and the author, and I hope to see the thankless and laborious but useful task of preparing a similar bibliographical record of British palæontological literature ere long undertaken by some public-spirited palæontologist.

As regards the second point to which I have adverted, namely the preparation of catalogues of the fossils of special formations and special countries, something has been already accomplished, and very much is in process of actual accomplishment.

Amongst work of this kind, which has been already done, the first place is due to the well-known "Thesaurus Siluricus" of Dr. Bigsby. It is to be regretted, however, that this veteran geologist did not enhance the usefulness of his valuable and laborious work by the citation of the references to, at any rate, the original descriptions of all the species catalogued; and it is to be hoped that this defect will be remedied in the "Thesaurus" of Devonian and Carboniferous fossils which he is now engaged in preparing. In the recently published "Catalogue of the Genera and Species of American Palæozoic Fossils," by Mr. S. A. Miller, references to the original descriptions of all the species quoted are given, and the usefulness of the work to students is thus greatly increased. The *magnum opus* in the way of catalogues, however, is the "Stratigraphical Catalogue of British Fossils,"[1] now in course of publication by Mr. Robert Etheridge, the appearance of which will be hailed by every student of Palæontology. A large portion of this gigantic undertaking has, I believe, already passed through the press, and the general plan upon which it is constructed is both scientific and comprehensive. Not only is each recorded British species cited under its proper place, but the quotation of each is accompanied by a reference to the work or works in which it has been described, together with a full synonymy of the species, and a statement as to its known range in time and space, along with a list of the British localities in which it has hitherto been discovered. Mr. Robert Etheridge, jun., following, *haud impari passu*, in the steps of his distinguished father, is engaged in the publication of a similar exhaustive Catalogue of Australian Fossils,[2] the general

[1] A Stratigraphical Catalogue of British Fossils. By Robert Etheridge, Esq., F.R.S., L. & E., F.G.S. 4 vols. 4to. Clarendon Press, Oxford.

[2] A Catalogue of Australian Fossils (including Tasmania and the Island of Timor), Stratigraphically and Zoologically arranged. By Robert Etheridge, Esq., jun., F.G.S. 1 vol. 8vo. University Press, Cambridge.

plan of which is equally comprehensive; and I am glad to learn that this important contribution to our science is not only actually completed, but that, through the liberal spirit of the University of Cambridge, its publication has been secured, and it is now passing through the press. When we shall have once secured a series of catalogues of this nature, dealing with the fossils of every country, we may for the first time expect that the complex subject of synonymy—at present the curse and opprobrium of Palæontology—will be brought within manageable compass.

Leaving the subject of palæontological literature, I propose briefly to direct your attention to some of the more important discoveries which have been made in Palæontology within the last few years; and in so doing I shall confine my short review almost entirely to the department of Palæozoology, if only for the reason that I have no claim to the possession of more than a general knowledge of the difficult subject of Palæophytology or Fossil Botany. As regards this latter branch of Palæontology, however, I may just notice the very important controversies which have of late arisen as to whether vegetable or animal fossils are entitled to take precedence in determining the stratigraphical horizon and geological age of any disputed group of strata, and there are at least two instances, in which these controversies have dealt with questions of great general interest. In one of the instances to which I allude we find an ancient flora co-existing with a more modern fauna; and in the other we have modern types of plants associated with old forms of animal life; but the problem to be solved is essentially the same in both cases. Thus in the Gas-coals of various localities in the uppermost portion of the Bohemian coal-strata a fauna of Permian facies (comprising characteristic Permian species of *Xenacanthus*, *Acanthodes*, and *Palæoniscus*) is met with in association with a characteristic assemblage of Carboniferous plants. High authorities, such as Feistmantel, Anton Fritsch, and Krejci, explain this upon the theory that the age of the beds must be determined by the character of their contained animal-remains, and they conclude, therefore, that the deposits in question are to be regarded as referable to the base of the Permian series, or rather as passage-beds between the Carboniferous and Permian. They regard this curious phenomenon, in fact, as being a case in which the flora of a given region has persisted, whilst the fauna has undergone a notable modification. On the other hand, other authorities (such as Stur and Weiss) are of opinion that the age of the beds should be determined from the character of the plants, and that the Bohemian Gas-coals are to be regarded as truly Carboniferous. The balance of evidence, however, is at present decidedly in favour of the former hypothesis.

The second controversy to which I have referred is of much greater importance, and concerns the boundary-line between the Cretaceous and Tertiary deposits of North America. In the Old World, as is well known, there is a great break between the highest Cretaceous and the lowest Tertiary sediments—a break marked not only by universal unconformity, but also by a great change in the characteristic fauna of the two deposits. On the other hand, in North America the highest unquestioned Cretaceous beds (the marine deposits of the Fox-Hills group) are succeeded by a great series of strata, well known as the Fort Union or Great Lignite series, the true stratigraphical position of which has been the subject of much dispute. These deposits consist of nearly four thousand feet of sandstones, shales, and beds of lignite, which rest quite conformably upon the unquestioned Cretaceous deposits of the Fox-Hills group below, and which are succeeded unconformably by unquestioned beds of Tertiary age. In their lower portion they contain a number of marine organic remains, but these gradually disappear as we ascend in the series, and its upper portion is generally characterized by the remains of land and fresh-water shells, associated with a vast abundance of vegetable fossils, chiefly of the nature of detached Dicotyledonous leaves. The difficulty of the problem as to the real age of this great and remarkable deposit arises chiefly from the fact that its marine fossils are fundamentally of Cretaceous type, whilst the remains of plants have an equally distinct Tertiary facies. Thus we find such characteristic Cretaceous Mollusca as *Inoceramus*, *Ammonites*, *Baculites*, and unquestionable Dinosaurians (*Agathaumas*) side by side with a luxuriant flora of an essentially Tertiary aspect, comprising such modern genera as *Quercus*, *Acer*, *Populus*, *Ulmus*, *Morus*, *Fagus*, *Juglans*, *Alnus*, *Corylus*, *Ilex*, *Platanus*, *Ficus*, *Cinnamomum*, *Smilax*, *Laurus*, *Rhamnus*, *Magnolia*, *Eucalyptus*, *Thuÿa*, *Sequoia*, *Abies*, *Taxodium*, *Sabal*, etc. Whilst this association of Cretaceous animals with Tertiary plants is undoubted, much difference of opinion obtains as to how it ought to be interpreted. On the one hand, high authorities, such as Dr. Heer, and Professors Lesquereux and Dana, are of opinion that the plants ought to carry the day, and that the Lignitic Group ought to be considered as the base of the Tertiary series. On the other hand, equally high authorities, such as Meek, Hayden, Cope, and Stevenson, are of opinion that the fauna carries more weight than the flora, and that the Fort Union or Lignitic series should be regarded as truly the summit of the Cretaceous. To this view Prof. Newberry, who is in the rare position of having attained almost equal eminence in Palæozoology and Palæobotany, gives his adhesion, and it is to be considered as in every respect the most probable view, if we take into account the fact that the disputed series is admittedly overlain unconformably by strata of undoubted Tertiary age. Upon the whole, then, when we take into consideration the general unreliability of terrestrial or freshwater mollusca as tests of age, and also the often unsatisfactory nature of stratigraphical conclusions based upon vegetable remains only, I think we can hardly avoid arriving at the opinion that the Great Lignitic series of North America is truly Cretaceous, though probably of a later date than any of the recognized Cretaceous deposits of the Old World.

Coming next to the Invertebrates, we find that the last decade has been prolific in discoveries and determinations of great interest and importance, only a very few of which I can notice here, even in the briefest manner. The first point in this connexion which demands our attention is the immense benefit which has resulted to palæontology from the introduction of the microscope as an absolutely indispensable instrument of palæontological research. The old "macroscopic" method of investigation, as the Germans have happily termed it, has been definitely abandoned; and no palæontologist would now, except under special circumstances, describe any doubtful or problematical Invertebrate fossil without previously having subjected it to a rigid examination by means of the microscope, at any rate in all cases in which his specimens would allow of this mode of examination. It is impossible, indeed, to exaggerate the immensely increased powers of observation and description which palæontologists have acquired by the practice of making transparent sections of fossils, suitable for microscopic examination. Already, the results of this method of inquiry have proved extremely important, and when its adoption has become more universal, we may expect an even more remarkable increase of our knowledge as to the intimate structure of many extinct forms of life, which are at present but very imperfectly understood.

Few departments of Invertebrate Palæontology have shown the beneficial effects of the introduction of the microscope into palæontological investigations more strikingly than is exemplified by the *Protozoa.* I could not adduce a better instance of this than is afforded by the remarkable and beautiful series of fossil sponges, which have been generally grouped together under the name of *Ventriculitidæ.* Though well known by their remarkable external configuration, and unhesitatingly classified in accordance with this character alone into genera and species, we had until lately really very little genuine knowledge as to the structure and affinities of these old types of life. They were originally regarded either as horny or as primitively calcareous sponges, which had undergone silicification; and it was upon this view that D'Orbigny, Fromentel, and other observers regarded them as a special group, to which the name of *Petrospongiadæ* was given. We know now, however, that the *Ventriculitidæ,* and a number of other equally interesting and beautiful groups of fossil sponges, dating from the Lower Silurian, are true siliceous sponges, belonging to the same great section as the exquisite Venus' Flower-basket and Bird's-nest Sponges (*Euplectella, Holtenia,* etc.) and other *Silicispongiæ* of recent seas, or, in other words, to such now thoroughly established divisions as the *Hexactinellidæ* and *Lithistidæ.* While referring to this subject, it is hardly out of place to notice the remarkable conclusions which have been reached by Zittel and Sollas as to the condition of fossilization of these sponges, since these conclusions materially affect our ideas as to the general process of fossilization, and as to the mode of preservation of the sponges and allied organisms in particular. We are all familiar with what is termed the "silicification" of fossils. We know that it is a very common thing to find organisms in certain strata in a "silicified" condition. In other words, we know that fossils which we can assert positively to have been originally calcareous, such as Brachiopods, Lamellibranchs, Corals, etc., are often found in some particular deposit to have been entirely and perfectly converted into flint. Not only is this silicification of calcareous organisms a very common phenomenon, but there is not the least difficulty in understanding how it occurs, since carbonate of lime is a very soluble substance and flint is a very insoluble one. Hence, any calcareous fossil, if subjected to percolation by water holding silica in solution, would be liable to have its lime dissolved away, and replaced by the more intractable flint. It is asserted, however, that in the case of the fossil sponges of which I have been speaking, as well as of some other fossils, the reverse change sometimes takes place, and that a structure originally siliceous becomes converted into carbonate of lime, or, rather, becomes replaced by this substance. It must be admitted that it is at present very difficult to comprehend how a skeleton of comparatively insoluble silica should be dissolved away, and should be replaced by the very readily soluble calcite, but the researches of Zittel in particular seem to leave no doubt as to the fact that siliceous sponges have occasionally undergone this change. The bearings of this discovery upon our investigations of the lower Invertebrate fossils are very wide indeed, and I can only point out here that in the absence of direct evidence, we must rely, in doubtful cases, upon the condition of fossilization exhibited by associated fossils, the original nature and constitution of which is beyond doubt. If we take, for example, the singular and problematical fossils grouped together at present under the name of *Stromatopora*, which I have had especial occasion to study, we find that some specimens exhibit a skeleton of flint, whilst others show one of lime; and the question, therefore, arises, whether the siliceous or the calcareous skeleton is really the original one? We find, however,—at least this is my experience,—that the siliceous specimens of *Stromatopora* occur in deposits in which the Brachiopods and Corals and other organisms which were unquestionably originally calcareous, also usually present themselves in a silicified condition. On the other hand, in those deposits in which such calcareous fossils as the Mollusca and Corals retain their original constitution, we find that the *Stromatoporæ* are also calcareous. Without, therefore, questioning Prof. Zittel's conclusions as to the mode of preservation of the fossil *Hexactinellids*, it remains certain that the question as to the originally siliceous or calcareous constitution of any particular class of fossils will have to be settled by an appeal to the rocks in which these fossils occur, and cannot be decided simply by an examination of isolated specimens in the cabinet of a collector. Moreover, without at all doubting that Zittel has proved his case, as regards the particular fossils which he has had under examination, we cannot avoid the conclusion that the replacement of silica by carbonate of lime must, in the nature of things, be an unusual phenomenon, and that, so long as we are ignorant of the precise method under which it is effected, we are bound to suppose that all fossils which are found to be sometimes siliceous and sometimes calcareous are really composed of carbonate of lime, unless distinct and incontrovertible evidence to the contrary can be adduced.

The Protozoan Group of the *Radiolaria* has been recently shown to have a much wider range in time than had been previously imagined, examples of it having been lately detected in the Carboniferous Limestone of Cheshire. These old types are apparently identical with the existing *Polycystina*, and their tests are siliceous. We must not, however, altogether lose sight of the possibility, though a very remote one, that these siliceous shells were primitively calcareous, and that they have simply undergone silicification. If this were really the case, we should have to believe that there existed in the Carboniferous seas a group of Rhizopods possessing shells similar to those of the recent *Polycystina* in *shape*, but composed of *lime* instead of *flint*.

As regards the fossil forms of *Foraminifera* our knowledge has been greatly increased of late years by the researches of H. B. Brady, Rupert Jones, Terquem, Hantken, and other well-known workers in this difficult field. Unquestionably the most important accession to the literature of this subject is Mr. Brady's masterly "Monograph of Carboniferous and Permian Foraminifera (the genus *Fusulina* excepted)," published in 1876 by the Palæontographical Society. Among special discoveries in this department the first place must be accorded to the detection by Mr. Brady of the living arenaceous genus *Saccammina* in the Carboniferous, and to the discovery by the same distinguished observer that the pre-eminently Tertiary family of the *Nummulinida* is represented in deposits as old as the Carboniferous by no less than three generic types (*Archædiscus*, *Amphistegina*, and *Nummulina* itself).

Much light has recently been thrown upon the structure and affinities of many of the fossil corals, not only by the extension to this puzzling group of petrefactions of the microscopic methods of research, but also by late zoological discoveries. Thus, Mr. Moseley has shown that the great reef-building genus *Millepora*, so abundant at the present day, and extending backwards into the Tertiary period, is truly referable to the class *Hydrozoa*, and not to the *Actinozoa*, in which it had been previously placed; whilst the genus *Stylaster* and its allies are also truly Hydrozoal. We are thus introduced to a new subclass of *Hydrozoa*—the *Hydrocorallinæ*—which possessed the power of building up a calcareous skeleton, and we may expect to find that these coralligenous *Hydrozoa* have played a more important part in past time than has hitherto been suspected. Again, Mr. Moseley has demonstrated that the living genus *Heliopora*, formerly placed with the *Zoantharian* division of *Actinozoa*, in the old group of "Tabulate Corals," is really a genuine *Alcyonarian*, and is therefore truly most nearly related to the living Red Coral, Sea Shrubs, Organ-pipe Corals, etc. This important discovery at once shows us the true position of a number of ancient types of Corals, such as *Heliolites*, *Plasmopora*, *Polytremacis*, etc., which are fundamentally most closely allied to *Heliopora*. Thus the *Alcyonaria*, previously unknown in deposits older than the Secondary, are shown to have commenced their existence at any rate in the Lower Silurian period.

The discoveries just referred to, in fact, together with the parallel investigations of palæontologists themselves, have greatly modified our conceptions of the old order "*Tabulata*," and, in the opinion of some, have fairly abolished this division. With the removal of *Millepora* to the *Hydrozoa*, and of *Heliopora* and its allies to the *Alcyonaria*, along with the discovery by Verrill that *Pocillopora* is a true *Perforate Coral*, the group of the Tabulate Corals has undergone serious mutilation, and it remains for future researches to show whether it can be retained as a separate division of the *Zoantharia*. In the meanwhile, it may be best retained for various ancient types of Corals which cannot at present be definitely referred to other sections (*Favosites? Chætetes? Syringopora, Halysites*, etc.).

The proposal of the late Prof. Louis Agassiz, adopted by many American palæontologists and zoologists, to remove the whole of the great group of the Rugose Corals to the *Hydrozoa*, is not, in my opinion, supported by sufficient evidence, and is contradicted by many considerations of great weight. Judging both from the structure of the extinct forms, and also from that of the aberrant living genus *Edwardsia*, it seems best in the meanwhile to regard the *Rugosa* as standing between the two great sections of the Zoantharian and the Alcyonarian *Actinozoa*.

Amongst the Echinoderms, one of the most noticeable points of progress is the light which has been thrown upon the structure of the strange and ancient group of the *Perischoechinidæ* by the discovery of the living flexible Echinoids, *Asthenosoma* or *Calveria*, and *Phormosoma*. Not only do we now know that old forms of these singular types existed in the Secondary period (the *Echinothuria* of the Cretaceous); but we further know that some of the still older Palæozoic *Perischoechinidæ* were furnished with imbricated plates, this structure communicating to the test a considerable amount of flexibility. Another point of interest as concerning this order is the establishment (through the labours of Wyville Thomson, Rofe, Billings, Wachsmuth, etc.) of the fact that the mouth of the Palæocrinoids was concealed beneath the perisome, entirely hidden from external inspection, and that the so-called "proboscis" was truly an excrementitious aperture.

The remaining groups of Invertebrates I must pass over with very scant notice, though our knowledge of their fossil representatives has been immensely increased in various directions in late years, and in some cases very interesting discoveries have been brought to light. Among the *Annulosa*, the most noticeable point is the gradual extension of our knowledge concerning the air-breathing Arthropods—the *Arachnida*, *Myriapoda*, and *Insecta*—of the Carboniferous period. To this, as usual, that indefatigable investigator, Mr. Henry Woodward, has largely contributed. Among the lower *Mollusca*, considerable additions have been made to our knowledge. Many new forms of *Polyzoa* have been described, and Prof. Young and Mr. John Young have shown us, in their investigation of *Rhabdomeson*, how much light may be thrown upon the structure of these minute and puzzling fossils by the method of examination by means of thin sections. Mr. R. Etheridge, jun., has made the curious discovery as regards the *Brachiopoda* that a small Carboniferous species of *Producta* was in the habit of attaching itself firmly to foreign bodies by means of the spines of the ventral valve. In this department, also, Mr. Davidson still continues to publish the series of supplements which will at last complete his magnificent "Monograph of the British Fossil Brachiopoda."

The proposal has recently been made, and has met with the approbation of many eminent zoologists, to remove the groups of the *Polyzoa* and the *Brachiopoda* to the group "Vermes," and to place them in the neighbourhood of the Annelida. The grounds upon which this step is advocated are derived wholly from the study of living forms, and, indeed, are principally based upon the similarity observed in the developmental processes of these animals. This change, however, is hardly likely to be accepted save by those who believe that Embryology is the real key to classification, and it certainly is not at present supported by any evidence afforded by the study of the fossil forms of *Polyzoa* and *Brachiopoda.*

As regards the higher *Mollusca,* an immense mass of valuable material has been accumulated in recent years by the efforts of many patient and able observers. It would take up too much time, were I to attempt to enumerate even the more important contributions which have been made within the last decade to this department of palæontology. I cannot, however, forbear a passing allusion to the great work on the "Invertebrate Cretaceous and Tertiary Fossils of the Upper Missouri Country," published last year by Professor Meek—a work which is not only in itself one of the most important contributions ever made to the history of the fossil *Mollusca,* but the appearance of which was followed, almost immediately, by the lamented death of its distinguished writer.

Passing on to the Vertebrates, we may notice the important light which has been thrown upon the past history of Fishes, by the discovery of two living species of *Ceratodus* in the rivers of Queensland. From this discovery we are enabled to speak with certainty as to the structure and affinities of the *Ceratodi* of the Trias, upon which Agassiz originally founded the genus, and which were only known by their curious dental plates. We are further enabled to vastly extend backwards the range of the Dipnoous Fishes in time, for this order, formerly believed not to occur in a fossil condition, is probably represented by the *Ctenodus* of the Carboniferous and the *Dipterus* of the Devonian, and it seems not unlikely that others of the so-called "Ganoids" of the Palæozoic period will ultimately turn out to be truly referable to the *Dipnoi.*

As regards the *Amphibia,* large accessions have been made to our knowledge of the *Labyrinthodontia,* chiefly through the researches of Cope, Miall, Atthey, etc. The first named of these observers has, in particular, described a large number of new and interesting forms of this extinct group from the Coal-measures of Ohio, descriptions and figures of which are to be found in the second volume of the Palæontology of Ohio. I may also add that we seem now in possession of sufficient evidence to justify us in asserting that the true Salamandroids (*Urodela*) existed in deposits at least as old as the Permian. Not only has Geinitz given the name of *Palæosiren* to a fossil from the Permian which he believes to be the remains of a Salamandroid, but Gaudry assigns the same position to the Permian fossils which he has recently described under the name of *Salamandrella*; and the last-mentioned palæontologist is inclined to believe that the Carboniferous genera *Raniceps* and *Apateon* are really Urodelans and not Labyrinthodonts.

As regards the Reptiles, the researches of Marsh and Cope have thrown much light upon the structure and affinities of the Mosasauroids and the Deinosaurs; and the view that the latter are related to the Struthious birds has been considerably strengthened by the new evidence which has been obtained. Another addition to our knowledge of the fossil Reptiles has been made by Prof. Marsh, who has discovered in the Cretaceous deposits of North America the remains of colossal Pterosaurs, closely resembling the Pterodactyles proper, but having the jaws destitute of teeth. The jaws must have been, in all probability, sheathed in horn, so as to resemble the bill of birds; and it is singular that there should have coexisted in Western North America *toothless* flying reptiles and *toothed* birds—an association which is not likely to be without its significance. Marsh proposes to elevate these edentulous Pterosaurs to the rank of a distinct order, under the name of *Pteranodontia*. Professor Owen, again, to whom fossil herpetology already owes such an immense debt, has founded the new order *Theriodontia*, for the reception of a number of carnivorous reptiles from deposits of Triassic or Permian age. The reptiles in question, of which *Cynodraco* is the type-genus, show some curious affinities to the *Carnivora* amongst the Mammals, as is more particularly marked by the fact that the teeth are in three distinct sets—viz. incisors, canines, and molars—and that the canines are very large and pointed. The Theriodonts thus differ from all other known reptiles, living or extinct, in their dentition, and they are also peculiar in the fact that the humerus is provided, as in various mammals, with a 'supra-condyloid foramen.'

Amongst the Birds there are two specially interesting discoveries to record, one of these being, perhaps, the most important addition to our knowledge of the structure of fossil birds which has been made since the discovery of *Archæopteryx*. I allude to the discovery by Marsh of the curious toothed birds of the Cretaceous deposits of North America. These extraordinary birds are so aberrant in their characters that they have been rightly raised by their distinguished discoverer to the rank of a distinct subclass (*Odontornithes*), comprising the two orders of the *Odontolcæ* and *Odontotormæ*. In the first of these orders we have only the marvellous *Hesperornis*, a huge diving-bird, standing between five and six feet high, and having its jaws furnished with numerous conical recurved teeth sunk in a deep continuous groove, the front of the upper jaw being alone edentulous. The breast-bone is destitute of a keel, and the wings are quite rudimentary, so that *Hesperornis* must have been entirely incapable of flight. On the other hand, it must have been an admirable swimmer and diver, and it probably lived upon fish, which it captured by means of its toothed jaws. Its tail was not long and lizard-like, as in *Archæopteryx*, but consists of about twelve vertebræ, of which the last three or four are amalgamated to form a flat terminal mass, there being at the same time clear indications that the tail was capable of up-and-down movement in a vertical plane, this probably fitting it to serve as a swimming paddle or rudder. The vertebræ of the cervical and dorsal regions are of the ordinary well-known ornithic type.

In the *Odontotormæ* — the second order of *Odontornithes* — the type-genus is the wonderful *Ichthyornis*, which, though apparently aquatic in its habits, differed from *Hesperornis* in having well-developed wings, constructed upon the usual ornithic type. The jaws were furnished with compressed pointed teeth, which were sunk in distinct *sockets*. The vertebræ, further, have the absolutely unique character—a character unknown in the entire class Aves—that their bodies were bi-concave. In this respect, therefore, *Ichthyornis* makes an approach to the Fishes, Amphibians, and Reptiles, in which amphicoelous vertebræ are common, or occur in certain groups. The tail of *Ichthyornis*, as of the allied *Apatornis*, is unfortunately not known.

The second discovery among Birds to which allusion ought to be made is that of the *Odontopteryx toliapicus* of the London Clay, described by Prof. Owen. This very singular bird exhibits the peculiarity that the osseous margins of the jaws are prolonged into tooth-like extensions, which are of two sizes, and which were probably encased in prolongations of the horny substance of the bill. These processes are triangular, compressed, and directed forwards, and they are not to be confounded on the one hand with the denticulations found in the horny sheath of the bill of various living birds, or on the other hand with the genuine *teeth* possessed by the *Odontornithes.* Professor Owen concludes that *Odontopteryx* was probably aquatic in its habits, and he regards it as a natatorial bird allied to the *Anatidæ.*

Coming, finally, to the Mammals, the discoveries which have been made within the last few years, more particularly those which have resulted from the researches carried on by Marsh, Leidy, and Cope into the Tertiary Mammals of North America, have been so numerous and so important, that my time to-night will not permit me to do more than simply to allude to a few of the more important ones, and more particularly to those by which changes have been effected in the previously existing systematic arrangement of the *Mammalia*, or which have fundamentally altered our conceptions of the character of certain groups.

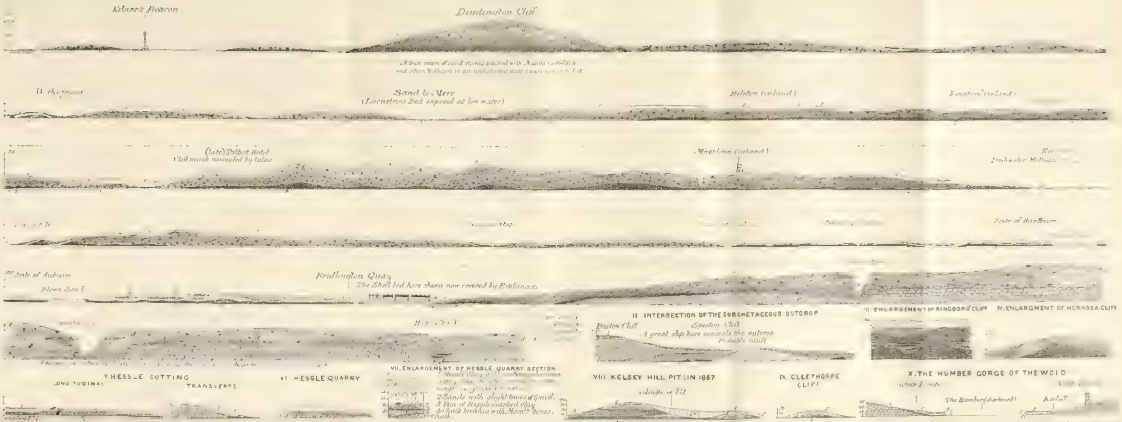
Among the Monotremes, Krefft records a gigantic *Echidna* from the Post-Tertiary deposits of Australia. As regards Marsupials, I may merely mention the recent appearance of Prof. Owen's magnificent work on the Fossil Mammals of Australia, in which will be found the fullest record extant of all that is known as to the wonderful extinct Marsupials which ranged over Australia in Post-Tertiary times.

The great order of the Ungulates has of late years been vastly added to by the discovery of entirely new forms, or of specimens more fully elucidating the structure of previously known forms. I can only advert to one or two points in this connexion. One of the most striking of Marsh's many discoveries is that of the two-horned Rhinoceros to which he gives the name of *Diceratherium.* This remarkable form is from the Miocene of Oregon; it differs from all the known two-horned Rhinoceroses in the fact that the two horns are placed transversely and symmetrically upon the nasal bones. In this respect, indeed, the genus differs from the whole group of the Perissodactyle Ungulates. Another discovery by Marsh is that *Coryphodon*, which is found in the Eocene of both Europe and America, though essentially Perissodactyle, possesses five toes to the foot, and thus differs from all other known Ungulates except *Orohippus.* Of the extraordinary series of forms by means of which the living genus *Equus* is connected with the Eocene *Eohippus* and *Orohippus* I need scarcely remind you, as the principal facts in this connexion are now widely known. Another, though less complete, series of connected forms is now known by which the genus *Dicotyles* is linked on to the Eocene *Eohyus*; and a third series exists by which the aberrant *Camelidæ* of to-day can be traced back to forms which agree with the typical Ungulates in having a full series of incisor teeth (e.g. *Poëbrotherium* and *Protolabis*).

Allied to the Ungulates in many respects, and forming a group intermediate between them and the Proboscideans, are the large Eocene Mammals which Marsh has raised to the rank of a distinct order under the name of *Dinocerata.* The fore-feet are five-toed, and the limbs are like those of the Elephants; but the most remarkable characters of these animals are those of the cranium. As regards the dentition, the upper jaw is destitute of incisors, but there is a pair of huge tusk-like canines, directed downwards, and there are six small molars on each side. In the lower jaw are six incisors, small canines, and twelve molars and præmolars. The armature of the head is also very peculiar. The upper jawbones carried each a pair of small processes, probably of the nature of horn-cores; the nasals carried two similar but smaller cores; and the frontals are developed into two larger bony processes apparently also intended to be sheathed in horn. There were thus three pairs of horns, similar in structure to those of the hollow-horned Ruminants. There does not appear to have been any proboscis, and the brain was proportionately smaller than in any known Mammal, either living or extinct, and even smaller than in some Reptiles. We cannot, therefore, credit *Dinoceras* with the possession of a large amount of intelligence.

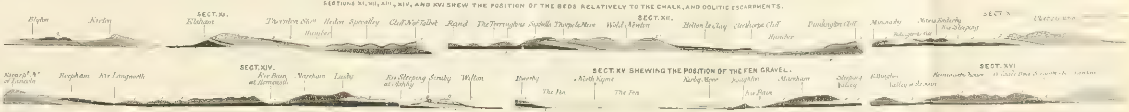
Another remarkable group of Eocene Mammals has been raised to the rank of a distinct order under the name of *Tillodontia.* These animals possess a curious combination of the characters of the *Carnivora*, *Ungulata*, and *Rodentia.* The general form of the skeleton most closely resembles that of the Carnivores, the skull being in many respects similar to that of the Bears, while the feet are five-toed, with the whole sole applied to the ground, and having ungual


N.B. The Great Chalky Clay has occasionally a bed of ... Gravel and Sand also occur ... over the unshaded parts of the Map. ... of sections 1 to 10 are ...




REFERENCE TO SECTIONS I TO X. GLACIAL BEDS a to d, viz.t a. The Great Chalky Clay full of rolled Chalk debris (No. 0 of the Norfolk Sections). b. Beds of dark sand and bands of a and c. c Purple Clay with numerous rock boulders and closely packed with the debris of formations older than the Chalk, but with the Chalk debris in subordinate quantity only, and passing up into, d. Clay with less débris of any kind and in which the Chalk débris disappears. c' Beds of sand in c, one of which, at Bridlington, yielded the Bridlington mollusca but is concealed by an extension of the Esplanade. c̄ Moraines of rolled Chalk co-eval with c and with bands of c and sand beds xx in them. d' Beds of sand and gravel in d. POST GLACIAL BEDS e to k, viz.t e The Hessle sand and gravel. f The Hessle Clay - fox coloured with bluish vertical partings and containing subangular chalk fragments, many small boulders (mostly rounded), and, occasionally, angular ice-grooved blocks. g Sand and gravel posterior to the Hessle clay, the sands having included beds of Gravel, g' ... of similar age. h Gravel composed chiefly of worn flattened fragments of chalk. i Valley Gravels, some with freshwater mollusca. k Recent Cyclas Marls. 1. Upper Oolite. 2. Neocomian. 3 The Red Chalk. 4 White Chalk. The dotted line denotes approximately the position of the Chalk floor.

SECTIONS XI, XII, XIII, XIV, AND XVI SHEW THE POSITION OF THE BEDS RELATIVELY TO THE CHALK, AND OOLITIC ESCARPMENTS.




REFERENCE TO SECTIONS XI TO XVI. a Trias. b Lias. c Lower Oolite. d Middle and Upper Oolite. e Neocomian. f Red Chalk. g White Chalk. 1 The Great Chalky Clay (a of the previous sections). 2 The Purple Clay (c of the previous sections). 3 The Hessle Clay ... the Fen gravel. N.B. All sands and gravels except the Fen gravel omitted.

phalanges similar to those of the *Ursidæ*. The præmolars and molars, on the other hand, have grinding crowns, the canines are small, and there are two incisors in each jaw, which agree with those of the Rodents in being of large size, in having chisel-shaped crowns, and in springing from persistent pulps.

One other discovery, also made by Marsh, I must just mention, and then I have done. The eminent palæontologist just alluded to has shown that the Lower Eocene of New Mexico and the Middle Eocene of the West contain a number of Lemuroid genera, higher in type than the existing Lemurs, but decidedly inferior to the Catarhine monkeys. The most remarkable point about the two principal genera of early Lemuroids—viz. *Lemuravus* and *Limnotherium*—is their generalized character. This is especially seen in the dentition, *Lemuravus* having no less than forty-four teeth, arranged in a continuous series, and *Limnotherium* having forty teeth.

I have now endeavoured to lay before you a brief account of some of the leading results which have been effected by the researches of palæontologists during the last few years. The field we have traversed is a wide one, and there are many parts of it which it would have amply repaid us to have considered in detail. I need hardly add, also, that I have been compelled by the exigencies of time to forbear altogether from even an allusion to many important accessions to our knowledge. One of the objects of this address will, however, have been gained if I have succeeded in convincing you that the Science of Palæontology is in a sound and healthy condition, not yet arrived at maturity, but growing actively, and likely to grow in the future. This ought to be the more satisfactory to us, as we may feel quite sure that it is to Palæontology, perhaps more than to any other Science, that we may look for the key to some most interesting and important theoretical problems in Biology.

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## II.—American "Surface Geology," and its Relation to British. With some Remarks on the Glacial Conditions in Britain, especially in Reference to the "Great Ice Age" of Mr. James Geikie.

By Searles V. Wood, Jun., F.G.S.

(PART III.)

(Illustrated by a large folding Map and Sections. Plate I.)

(*Concluded from* Dec. II. Vol. IV. *page* 551.)

I HAVE, in the foregoing, endeavoured to set out the general conditions under which that one principal Glacial deposit of England which I term "Upper Glacial" was accumulated, according to the views to which I have been led by several years' active examination of the area occupied by it, and a still longer study of the phenomena observed. They differ materially in many respects from the views urged by Mr. Jas. Geikie in his "Great Ice Age," and continued observation will help to determine which can best be reconciled with the facts; but before leaving the subject of this formation, I must observe that the diagram and description by Mr. Skertchly of the manner in which Lincolnshire was glaciated, as imported by Mr. Geikie into his book, conveys what I regard as an erroneous view.

According to that diagram[1] and description, the morainic material is represented as having been derived from ice moving from N.E. to S.W., that is to say, from the coast inland, and transversely to the strike of the formations from which its moraine was derived; in fact, from the direction of Scandinavia. The moraine also is represented as though it extended over the Chalk Wold, and the whole of it had come from N.E. to S.W. by a process of push or overlap, extending a little way only however, and not so as to prevent the morainic material being mainly identical with the formation on which it rests. These things do not, in my experience, accord with the facts. With the exception of the part to which I have already adverted near Flamborough Head, and the mouth of the Pickering glacier-trough, and some very small patches elsewhere (one of which is on very high ground at Huggate), the Chalk Wold is destitute of Glacial clay of any kind, both in Yorkshire and Lincolnshire. Where it abuts against the western side of the Lincolnshire Wold, the morainic material certainly assumes its most chalky aspect, becoming little else than reconstructed Chalk, but its path has been mainly parallel and not transverse to the Wold. This would have been seen if a map which I drew of the Glacial and Hessle beds over Lincolnshire and South-east Yorkshire (and which accompanied the author's private copies of the Memoir by Mr. Rome and myself) had been allowed to appear in the Journ. of the Geol. Soc. To remedy that defect, and to render the views discussed in the present paper more intelligible, I have given by photo-lithography a plate which contains a map of South-east Yorkshire and most of Lincolnshire, with the sections in illustration of it, which formed one of several that I some years since prepared for a work on the later Geology of East Anglia, which I contemplated, but which failure of health and other reasons made me relinquish.

From this map it will be seen that the moraine to which the chalky clay of East Anglia owes its origin (and which is indicated on it by the black shading with white dots) streamed down from the north-west in the great trough between the Chalk and the Oolitic escarpments of Lincolnshire; from whence expanding southwards it spread over the Eastern and East Midland counties. Its northerly diminution and eventual cessation some way south of the Humber shows, I consider, that the morainic chalky clay is not in the position in which it was generated beneath the ice, as Mr. Skertchly's diagram assumes, but that most of it has travelled and been deposited far from its place of origin; while its absence to the west of the Yorkshire Wold is altogether repugnant to that motion from the coast inland, upon which in the case of Lincolnshire Mr. Skertchly insists. Between Castor in North Lincolnshire and a point a few miles south of York, Mr. Rome and I could find no

[1] Great Ice Age, p. 358. The diagram itself appears to be an application to the case of Lincolnshire of the one given by Mr. Tiddeman in illustration of the formation of Till in North Lancashire and the adjacent country, in the 28th volume of the Quart. Journ. of the Geol. Soc. p. 481.

trace either of it or of any other kind of Glacial clay, and unless it be concealed beneath the marshes of the Ancholme and those on the north of the Humber, there does not appear to be any glacial clay between those limits, though there is some sand and gravel;[1] but near York another great sheet of Glacial clay (destitute entirely of chalk and sometimes destitute of boulders) begins, and, capped in its lower elevations by the Hessle beds, extends uninterruptedly northwards through the great vale which lies between the Pennine Hills on the west and the Howardians and Eastern Moorlands on the east, and is continued through Durham and Northumberland. This sheet represents in my view the material produced by the glacier-ice after this had shrunk back through the Vale of Pickering and the Humber, and deserted the chalk country and the Lincolnshire troughs; and it is, I consider, of the same age as that which, lying north of the Wolds and extending along the maritime border of Durham and Northumberland, succeeded the purple clay of Holderness. Looking at the distribution of the chalky clay thus shown on the map, and at the character of the chalky clay which forms the basement portion of the thick mass of which South-east Holderness is made up, it is clear, I think, that the moraine engendered north of Castor (except such as went northwards round the angle of the Wolds and through the Pickering trough), travelled out through the gorge of the Humber to form this basement clay of Holderness, which teems with rolled chalk and is also largely made up of the spoil of the clays which intervene between the Trias and the Chalk; and that the moraine which makes up the extensive clay deposit of the Eastern and East Midland counties has been almost entirely generated south of the Humber and north of the southern edge of the Fenland.

By the motion of this land-ice down Lincolnshire from north-west to south-east along the side of the Wold, the moraine necessarily corresponds there in a great degree with the formations on which it rests, and from which it was derived. From the motion too of the ice being from the higher ground to the lower, simultaneously with and independently of the general southerly and south-easterly motion of the whole mass, the debris degraded from the Wold travelled off it into the trough on its south-western side to form part of the great stream of intermixed morainic matter which, passing down this trough, spread over the Eastern and East Midland counties. By such motion of the ice, the moraine of pure Chalk which resulted from the degradation of the Wold does in some places overlie and overlap that produced from the degradation of the Jurassic clays, though by no means in that general way which Mr. Skertchly's diagram would imply; and this motion will explain how Mr. Skertchly's observations, being directed to the southern extremity of

[1] There is some thin clay over the Permian north of Doncaster, but whether this is referable to the Glacial or to the Hessle clay I am unable to say. There is also much sand, which is partly capped by clay, between Retford and Doncaster, but these are to the west of the line referred to in the text. Beds of sand and gravel also cap the Liassic and Oolitic escarpments of the extreme N.W. of Lincolnshire. These were called by Mr. Rome and myself "Denudation sands," but they may possibly represent the purple clay.

Lincolnshire, and to the Fen and other country adjoining it, have, I think, led him to the views which he expresses by his diagram and description. I should, however, have thought that it would have occurred to him that such material as that of which the chalky clay of the Eastern counties is composed, comprising as it does the debris in abundance of all rocks from the Chalk to the Lias, and extending in one direction to the coast of Suffolk, and in another to the brow of the Thames Valley, could not have resulted from the action he represents. Had it done so, instead of consisting of the large proportion of Jurassic debris that it does, we ought to find a belt of it on the north-east side of these counties formed of Crag and Eocene debris only, succeeded south-westwards by one of Eocene and Chalk debris only, and on the west of those counties by one of Chalk only, all of them free from Jurassic debris of any kind; but, as is well known, nothing of the sort exists. Similarly, also, had this N.E. to S.W., or Scandinavian direction of the moraine prevailed over the Wold, the western side of some of its northern or Yorkshire portion should have been flanked with a similar mass of reconstructed chalk to that which flanks its southern or Lincolnshire extremity; but none of it is so, though there is an abundance of flint gravel there, which I consider belongs to a later date—that of the Hessle-beds probably.

So far from ice moving from Scandinavia having had any part in the glaciation of Britain, I can discover no evidence either of the action or influence of any other ice than that which descended from British mountains; and notwithstanding all that has been urged by Dr. Croll or Mr. J. Geikie to the contrary, I contend that no ice extraneous to Britain had any part in its glaciation; and that throughout the Glacial period open sea existed between Britain and Scandinavia, though at or after the close of it the southern portion of the North Sea between England and Holland became converted into land.

Having dealt with what appear to be the formations attending the inception, culmination, and wane of the major glaciation or true Glacial period, I now come to the formations immediately antecedent to, and those synchronous with, and succeeding the minor glaciation; that is to say, to the formations of the post-Glacial period.

| English. | St. Lawrence Basin. |
|---|---|
| The series of beds *posterior to the general emergence of England.* This series includes the Hessle beds and their equivalents of the north-east; and the Middle sand and Upper Boulder (Brick) clay, their equivalents in the north-west. Also the mud-bed of Selsea and its overlying gravel with great erratics. Also the river-gravels and brick-earths with Palæolithic implements, some of which are of much earlier origin than others. During the formation of the beds of this series, especially of the older part of it, great changes were taking place in the distribution of land and sea over England, due to the continuation of the disturbances which commenced under the Upper Glacial sea. | The forest surface and its associated beds with great mammalia that rest on the Erie clay. The beds *3a* which overlay this forest surface. The marine clays of the Lower St. Lawrence. The terrace formation of Ohio (beds No. 4) and the Kames and Eskers of the Canadian Highlands. |

Part of the beds of the St. Lawrence basin above tabulated with the English beds posterior to the general emergence, have already been tabulated beside the English Middle and Upper Glacial; but having given my reasons for thinking it probable that they may not be synchronous with these, but be posterior to the major glaciation, I have now placed them in the position of synchronism to which the probabilities seem to point.

In the American portion of the deposits thus tabulated, the first, or forest beds, seem to me, if *in situ*, to have been formed during that temperate period which, following the elevation of England from the chief part of its general submergence, was accompanied there by the reintroduction of the great mammalia, and succeeded by the minor glaciation. The beds 3*a* appear to me to mark the culmination of this minor glaciation when the dissolution of the glacier which rested on the Canadian Highlands filled the lake-basin with freshwater, over which berg and other ice floated. The marine clays of the Lower St. Lawrence and Atlantic coast seem to me to belong to the same period, when in Lower Canada the glacier-ice terminated in the sea-water of the Gulf of St. Lawrence, and to have accumulated in the sea which followed the recession of the ice until the area they occupy was raised above its level.

The Eskers and Kames of the Canadian Highlands seem to me to mark the wane of this minor glaciation, and to represent the moraine of the ice after it had ceased to reach the sea or lake-waters; while the successive terraces formed by the beds No. 4 indicate the successive falls in the water of the lake-basin, as the ice of this minor glaciation wasted out of the narrow throat of the St. Lawrence valley, and so allowed the waters to escape from the lake-basin into the Gulf of St. Lawrence.

As already observed, the Mississippi Bluff formation appears to have been in progress throughout both the Glacial and post-Glacial periods, that is, throughout the major and minor glaciations.

In the English part of the deposits last tabulated, there has long seemed to me to have been one return of cold after the country had emerged from the depression at the end of which the Moel Tryfaen sands were formed, and had become stocked with the great mammalia.

In describing the beds of South-east Yorkshire and Lincolnshire, in the year 1867,[1] Mr. Rome and I distinguished those which appeared to us of Glacial age from certain others which, overlying these, were unconformable to and overlapped them in the direction of the Chalk Wold. These overlying and overlapping beds we called the "Hessle," and referred to the post-Glacial period, *i.e.* to a time posterior to the general emergence of the country from its great depression and glaciation. These beds, consisting of a fossiliferous sand and gravel confined to low elevations, and of a clay with boulders (mostly very small, but occasionally of larger dimensions), and other debris overlying it, and reaching to higher elevations than the gravel, we subsequently to the publication of our paper traced to the borders of Durham; and, in the case of

[1] Quart. Journ. Geol. Soc. vol. xxiv. p. 146.

the clay, up to elevations exceeding 300 feet in the Eastern Moorlands of Yorkshire. From information, also, given me by Mr. Topley of the Geological Survey, the same beds appear to be represented partly in the form of an upper clay with boulders, and partly in the form of gravels that have derived their debris from the Cheviots, which occur over the lower elevations of Northumberland, *i.e.* over the plateau country which forms the eastern portion of that county; and in all probability they extend into Scotland. Similar beds in the form of a (so-called) Middle Sand and Upper Boulder (Brick) clay with occasional boulders extend over the lower ground intervening between the Pennine chain and the coast in Cumberland, Lancashire, and Cheshire; and they reach along the north-west coast as far south at least as the north of Carnarvonshire. Probably also the sands and clays of the Severn Valley containing marine mollusca of similar recent character to those found in the Hessle and Fen gravels, and in the upper clay and middle sand of the north-west, which have been described by Mr. Maw (and the shells of which he kindly sent me for examination), belong to the same period. The southern limit of the Hessle clay appears to be at Firsby, on the northern edge of the Lincolnshire Fen; and, so far as I know it, the southern limit of the upper clay of the North-west of England appears to be at the same latitude in the Menai Straits, but on the eastern side the gravels of the formation carry the submergence a little further south, viz. over the Cambridgeshire Fen.[1]

On both sides of England, therefore, a similar degree of refrigeration and limited submergence, giving rise to these beds, seems to have occurred; this submergence (*not the glaciation*) shading off southwards to evanescence on the eastern side between lat. 52° and 53°; but on the west it may have extended further. The gravels of this formation, which in the Cambridgeshire Fen extend southwards to about lat. 52° 30′, are there and over the Fen northwards uncovered by Boulder-clay,[2] but in Holderness they are so covered. The marine molluscan fauna of these gravels differs in character from that of the East Anglian Glacial beds, in that it contains none but species which live either in British seas or in the seas immediately north of the Shetlands, whereas the Glacial beds of East Anglia contain some species that are unknown living, and others which, if living, are represented by species not known as such nearer than the North Pacific. Intermingled with the mollusca of these gravels both in Yorkshire and

[1] The distribution of this (Fen) gravel along the northern edge of the Fen and where it approaches near to the Hessle clay is shown in the map, and its position relatively to the chalky clay in section xv.

[2] A stony clay, a few feet thick, which covers unconformably the Lower Glacial formation on the Norfolk coast, between Mundesley and Eccles (lat. 52° 48′ to 52° 51′), and which there rises to an elevation of about 40 or 50 feet above Ordnance datum, seems to belong to this formation. The molluscan fauna of the Hessle gravel and its equivalents in the East of England are given in the tabular list to the supplement to the "Crag Mollusca," in the volume of the Palæontographical Society for 1873.

in the Fen district there occurs in certain localities a profusion of the river-shell *Cyrena fluminalis,* which now lives in the Nile and in the rivers of Thibet and China, and which is fossil in Italy and other places, as well as in the gravels of the Somme, the Thames Brick-earth, and at Barnwell near Cambridge, and which also lived during the later Crag and earliest Glacial formations. The presence of this shell, which seems peculiar to running water, proves that the valleys of the lower grounds were, during the Hessle gravel, occupied by rivers of water and not glaciers, but the valleys of the higher and mountainous regions may at this time have been occupied by glaciers, and, indeed, during the formation of the overlying Hessle clay, were, as it seems to me, so occupied. The debris shed out by these glaciers, together with that supplied from the coast waste of ground at lower altitudes than the mountains, such as the Yorkshire Wolds and Moorlands, the Durham Permian terrace, etc., appear to me to have furnished the material of this clay.

The completeness of the break between these formations of the minor glaciation and those of the major, as well as the considerable period covered by it, is shown partly by the way in which the purple clay (*c* and *d*) has been removed by denudation prior to the deposit of the Hessle beds, so that the Hessle clay wrapping over the denuded edges rests in the valleys, which are cut through the purple and down to the basement clay (*a*), on that clay itself; and partly by the occurrence of the *Cyrena* in gravels of Hessle age, and of mammalian remains in the breccia at Hessle (bed No. 4 of Section VII.); for these furnish evidence that the interval indicated by this break was accompanied by the introduction of a terrestrial fauna.

Mr. Thomas Jamieson, in a paper read before the Geol. Soc. of London in 1874,[1] has endeavoured to show that after Britain had arisen from its great submergence, the valleys of the Scotch Highlands were filled with glaciers, which in some places reached to the sea; and that to the glaciers of this period the Kame drift of that region is due; and as I have already observed and explained in detail while discussing the Ohio Eskers, an examination which I made in the year 1870 of the drift of the Scotch Highlands leads me to agree with Mr. Jamieson in this view.

We have been furnished with a description of the Glacial features of the Westmorland mountain district by Mr. J. C. Ward, in three papers read during the years 1873-4-5, and published in the Journal of the Geol. Soc. of London (vols. xxix. xxx. and xxxi.). Mr. Ward considers that we have evidence there of three periods; the first being that of confluent glaciers, or ice-sheet, the origin of which he regards as altogether British, finding no indication of the action of any ice-cap from the Polar regions. He also observes that he cannot find any facts *to suggest a cutting up of this period by several mild seasons.* The second period is that of submergence and amelioration of temperature; and the third that of a minor glaciation which the district *underwent subaërially,* and in which the glaciers were not confluent, but confined to the valleys. This

[1] Quart. Journ. Geol. Soc. vol. xxx. p. 317.

period of minor glaciation appears to be that which we are now considering, and the only divergence between the opinion to which Mr. Ward appears to have been led from a study of this district and that to which I have been led by a study of the East and South of England, consists in the submergence which he regards as having followed the first and principal glaciation, and preceded the minor one; my view being that the first glaciation and the submergence were coincident, and that the sea merely took the place of so much of the ice as was below its level, as this wasted away before amelioration of climate.

In reference to this divergence of opinion I would observe that the features displayed by the Lower Glacial series of beds in Cromer Cliff present, as it seems to me, the clearest evidence of the increase of submergence having taken place coincidently with the increase of glacial conditions on the Eastern side of England up to that stage in the Glacial period to which the Lower Glacial series of deposits carry us—a part of the geological record, be it remembered, which has been erased from any other part of Britain that may once have furnished it, but which carries us onwards from the latest Crag deposits with no more than an insignificant break.

If, therefore, the glaciation came on in the North-west of England without submergence, and its disappearance there was followed by this submergence, it follows that a complete oscillation must have occurred between the two sides of England, so that when the East and South-east of England was rising, as it was during the later part of the Upper Glacial formation and earlier part of the post-Glacial, the west and north-west must have been going down; but the red and white chalk, derived from the Lincolnshire glacier, which generated the chalky portion of the Upper Glacial, having got into the gravel at nearly 500 feet elevation so far west as the old strait between Ebrington Hill and the main island of the Cotteswolds, seems strong evidence that the submergence of the west side of England was to this height at least contemporaneous with that of the East, when this glacier terminated in the sea in the way described in a previous part of this paper. On the other hand, it must be admitted that the character of the marine mollusca from the beds of the Severn Valley is so much more recent and British than is that of the mollusca of the East Anglian beds, even up to the horizon of Bridlington and Dimlington, that they can scarcely be synchronous. This objection, however, applies equally to the Mollusca of the Lower Boulder-clay of Lancashire, and to that found in the Glacial clay of Yorkshire north of the Wold-scarp, while the gravels of the South-west which contain the Lincolnshire debris have not yielded any molluscan remains. It is not unlikely, therefore, that after the elevation which followed the Contorted Drift of Cromer, there set in coincidently with the further emergence of East Anglia an increase of the submergence northwards and westwards, and that this accompanied, and perhaps caused, the retreat of the ice from East Anglia, while the North and North-west remained enveloped by it. The giving place by the Holderness

Glacial clay of pure morainic origin to clay presenting the aspect of having been due to marine deposit only, when the submergence was great enough to cover the Wold near Flamborough to elevations of more than 400 feet, rather favours such a view; and I have long contended that this difference in the mollusca arises from the Lancashire and other northern clays of Glacial age having been formed at the close of the Glacial period, when the Crag-like fauna of the East Anglian Glacial beds had changed into that purely recent and Europeo-Arctic one which occurs in these clays, and in the Moel Tryfaen bed; up to which time the ice prevented the accumulation of any deposit in that part of Britain.

The description given by Mr. Ward of the mounds of stratified sand and gravel in the Lake-country, which he refers to the period of submergence, so precisely corresponds with the Kame drift of the Scotch Highlands, that I think they must belong to the same class of Glacial phenomena, and not be deposits of the period of submergence at all. Indeed, if we consider that wherever the marine sands of the submergence period lay in the way of the glaciers of the second glaciation, they must have been ploughed out and destroyed, we need not wonder that the instances which have occurred of the sands and gravels of this period, such as those at Moel Tryfaen and near Macclesfield, should be so rare as they are, though they are sufficient to prove the great depth of the Glacial depression in those parts of England.[1] These mounds, Mr. Ward says, are, at whatever elevation they occur, topped with erratic blocks; and he deduces from this circumstance the inference that the period of the gravels was a mild one, and was followed by a colder, in which these blocks were scattered over them. Precisely the same feature is, however, exhibited by the Scotch Highland Kames, and the explanation of it which I adopt is different from that of Mr. Ward, and is that as the washing out of the subglacial moraine into gravel took place by the melting back of this nonconfluent glacier-ice subaërially, the moraine of blocks which travelled on the surface of the glacier fell from its termination on to the surface of the gravel-heap thus produced.

Be this, however, as it may, we appear to have in the mountain districts of both England and Scotland precisely such a period of minor or nonconfluent glaciation as that to which Mr. Rome and I first, in 1867, and I in several papers subsequently (especially in one with some detail of circumstances which appeared in the Geol. Mag. for April, 1872), drew attention as explaining the origin of

[1] It is not, indeed, unlikely that the polished and broken fragments of shells which occur in the gravels of some of the Welsh valleys, such as that of St. Asaph (some of which were sent me by Prof. Hughes), and even those in the Upper Boulder-clay and Middle Gravel of the North-western counties, of which several small collections from Cheshire and Lancashire have passed through my hands, got into these gravels and clays of the Hessle period in this way; and the same remark applies to the Caithness clay, the shells of which are promiscuously scattered through its mass, and are of a far less Arctic character than those of Elie and Errol. The glacier which during the minor glaciation filled the great valley of the Caledonian Canal probably at its commencement ploughed out the marine gravels from that valley, and carried them into the Caithness clay then in course of formation.

the Hessle clay and the Upper Boulder-clay of the North-western counties of England; and taking into consideration the latitude and degree of glaciation in the various parts of Britain over which the formations of the period of minor glaciation which I have in the foregoing description supposed to be synchronous occur, there appears to be a general correspondence between them both in climatal conditions, and in the recent character of the mollusca wherever these latter are present.

Mr. Tiddeman also, whose attention has been chiefly directed to the Lancashire mountain district, has in a paper read before the Anthropological Institute on the 22nd May, 1877 (Nature, vol. xvi. p. 70), expressed in precise terms his belief in there having been a period of major glaciation, of which the evidences are most apparent in the central or less northern parts of our island, and a period of minor glaciation whose evidences are confined to those northern parts; while Mr. J. Geikie in the second edition of his "Great Ice Age" takes a similar view of the synchronism of the Hessle beds, the beds of the north-west, and of the gravels of the Highland valleys, to that which I have done; and I am gratified to be able so far to agree with all these gentlemen.

To this same time or nearly so, and long after the warmer waters of the Biscayan and Lusitanian coasts had at the close of the major glaciation been separated from the colder waters of the North Sea by the conversion of a portion of that sea into land, I have referred the gravel with great erratics of the Sussex coast which overlies the marine mud-bed of Selsea, first described by Mr. Godwin-Austen (whose list of shells was largely added to by Mr. A. Bell), containing semifossilized mollusca of southern facies all still living in South British and Lusitanian waters, but among which are included some that do not now range so far north as the British Channel. The erratics of the gravel and clay which overlie this formation are referred by Mr. Godwin-Austen to the action of coast-ice drifting from the French side of the Channel.[1]

We have thus, according to my apprehension of the case, a convergence of evidence to show that a well-marked interval of minor glaciation following upon the occupation of the sea-bottom along the Southern coast of England by a fauna indicative of water somewhat warmer than that of our present British Channel, of our rivers by the *Cyrena fluminalis*, and of the land by those mammalia whose remains are present in the breccia at the base of the gravel at Hessle (some of whose remains also, according to Mr. Godwin-Austen, are associated with the marine mollusca in the Selsea mud-bed), took place during the period which, from its having been posterior to the elevation of Britain from its great glacial submergence, we have for more than a quarter of a century been accustomed to call post-Glacial.

[1] A restoration of the supposed geographical features of the British Channel at this time according to my views is given in the fig. No. III. of the Sheet of Maps and Sections which accompanies my paper on the Weald in the 27th volume of the Quart. Journ. of the Geol. Soc.; see also Geol. Mag. Vol. III. p. 348.

Geologists have so long been cognizant that a minor glaciation occurred in Switzerland subsequently to the first and great extension of the Alpine glaciers, that it is unnecessary for me to do more than cite it in corroboration of the conclusions to which an analysis of the evidences offered by Britain and Eastern North America seem to me to point; while according to the abstract of a paper by Mr. G. M. Dawson on the Superficial Geology of British Columbia (read before the Geol. Soc. of London on 20th June, 1877), this gentleman discovers on the north-west side of North America similar evidence of two glaciations divided from each other by a warm period.

The semifossiliferous condition of the Selsea shells coupled with their recent and more southern facies is not the only indication of a warmer marine climate having occurred in Northern Europe at a very late date geologically speaking, for Torell and others found in Spitzbergen some beds of what are called by them "post-Tertiary" shells, containing *Mytilus edulis,* which is not known as now living there; and Nordenskiöld (Journ. of the Geograph. Soc. 1869, p. 136) speaks of these beds as containing plant-fragments and *subfossil* marine shells, of which some now first occur in living condition in the northern part of Norway. This recent, more southern, and subfossil condition of the Spitzbergen shells, is just that of the Selsea ones, and is altogether in contrast with that of the shells of all East Anglian Glacial (in the sense I use that word) deposits, which are thoroughly fossilized, besides containing among them forms characteristic of their superior age. Indeed, some of my Bridlington shells imbedded in indurated sand are in the condition of Oolitic fossils; for which but for their species they might be mistaken.

Mr. Geikie in the second edition of his work having made copious reference to the Hessle beds as described by myself and Mr. Rome, and (though making some confusion between our views and those of the late Prof. Phillips [1]) having also adopted the view of their position in the general sequence of deposits for which we contended, as well as their correlation with the upper clay and (so-called) middle sand of the North-west of England, which I have for several years past suggested,[2] the only difference that seems to remain between us in reference to them concerns the mode in which the clay originated. This clay Mr. Geikie insists is not only terrestrial in its origin, but is a morainic accumulation over a land-surface, beneath an ice-sheet, and left where engendered. I on the contrary have contended, and still maintain, that it is a submarine accumula-

[1] Professor Phillips not only never recognized what we contended was the true position of the Hessle beds relatively to other Glacial or post-Glacial deposits, but he had not up to the time of our paper even recognized that the Hessle beds were distinct from the mass of the Glacial clay of Holderness, which latter he then regarded, not only as identical with the ordinary Glacial clay of East Anglia (Upper Glacial or great chalky clay), but as identical also with the (Lower Glacial) beds of Cromer Cliff.

[2] Report of Brit. Assoc. for 1870, Geol. Mag. April, 1872, p. 176, and Sept. 1876, p. 396 (footnote). In a paper also "On the Climate of the Post-Glacial Period" in the same Mag. for April, 1872, p. 153, I drew attention to what appeared to me to be evidences of the recurrence of a glaciation of minor extent during that period.

tion, which, though it may be partly, is not wholly of morainic origin; neither has it been left (in Holderness, at least, where it rests on fossiliferous stratified sands) by submarine ice-recession, as has been the case with so much of the Upper Glacial clay. Further north, and also at its higher elevations, such may have been its morainic origin, but in Holderness and East Lincolnshire it presents very little appearance of morainic derivation at all; for the Chalk which it contains is not only small in quantity in comparison with the basement (Glacial) clay of that district, but *is subangular*, whereas that of the Glacial clay is *all of it rolled.* Moreover, as it occurs directly over the basement clay (of Upper Glacial age), which is densely crowded with Chalk debris, it ought, occupying the same place in reference to any ice-sheet, and seeing that nearly all the Chalk Wold would, by being left bare of Glacial clay, have supplied it with Chalk debris, to be equally crowded also if it had originated in the same way. Mr. Geikie illustrates his argument of its origin by figures of sections which show not only the junction of the clay with the sand to be irregular, but to be accompanied by the protrusion of a portion (or leg as he says the workmen called it) of the clay into the sand (Great Ice Age, p. 376). This, however, is a feature which may be met with occasionally in the case of the chalky (upper Glacial) clay resting on the middle Glacial sand in East Anglia, where also a much more marked irregularity is not unfrequently to be met with, which at one time misled me into the idea that a small fault had occurred in those places. They, however, all now seem to me explicable by the material in these cases having fallen not only *en masse*, but with the mass possessing a ragged or irregular form. I have already explained the reasons which forbid my believing that in any case, either where these quasi-faults occur, or where the clay rests on the sands with an even line, the morainic material could have been pushed over the sands by glacier-ice; and my conviction why such cases can only be reconciled with the dropping of the material on the stratified and undisturbed sands containing marine organisms upon which it reposes, while these sands formed the sea-bottom unincumbered *in that part* with glacier-ice; and there, with that of the leg described by Mr. Geikie, I leave the question.

Mr. Geikie, however, is silent on the fact that I have from nearly the outset of my investigations, and long before any one else took the view, urged that the Hessle beds were synchronous, or nearly so, with the *Cyrena* brick-earths of the Thames Valley;[1] so that he argues this synchronism as though the view were new to him; and Mr. Skertchly seems, in lecturing lately at Norwich, to have been in similar ignorance of my long contention on this head. Mr. Geikie also takes exception to my nomenclature of these beds as "post-Glacial," insisting that they should be called "Glacial"; but had I not called them what I did, my contention of their synchronism would

[1] See Quart. Journ. Geol. Soc. vol. xxiv. p. 174 (Nov. 1867); vol. xxvii. p. 22 (Nov. 1870); Geol. Mag. Jan. 1870, Vol. VII. p. 19; and April, 1872, Vol. IX. p. 176.

have produced great confusion. The memoir of Mr. Prestwich in the Philosophical Transactions of 1864 was, at the time of the paper by myself and Mr. Rome, the principal work of reference relating to the beds yielding *Cyrena fluminalis*, which either then had, or since have yielded Palæolithic implements; and Mr. Prestwich in pointing out that some of them afforded clear evidence of having been deposited while ice-action, so far as rivers were concerned, was in progress, designated them as post-Glacial only because he regarded them as posterior to the Boulder-clay of the Eastern and East Midland counties (the chalky clay), a formation which was then regarded as the one great and only clay accumulation of the Glacial period on the Eastern side of England, but which I have long been endeavouring to show was preceded by the Cromer Cliff beds, and succeeded by the Hessle.

In this way the beds yielding *Cyrena fluminalis*, in common with many other gravels yielding Palæolithic implements, but which did not contain that shell, though yielding other freshwater mollusca (which in some instances may have arisen from their being more remote from the sea or tidal water to which the *Cyrena* seems to have had some proclivity), came to be regarded almost universally by English geologists as post-Glacial; and it was expressly with the object of preventing confusion that I called the Hessle beds, which, in Holderness at least, did not appear to me to possess the same characters as are presented by the beds which I call Lower and Upper Glacial, but yet were, in my opinion, synchronous with the *Cyrena* brick-earths, "post-Glacial" also. In so doing, however, both in our coast section and in the descriptive part of our paper, Mr. Rome and I specially pointed out their anteriority to other river and later valley-gravels of Holderness, some of which where intersected by the coast, as at Hornsea, are of considerable thickness, and interstratified with clay laminæ containing freshwater shells; and the position of these may be seen in Section I. of the Plate which accompanies this paper. Thus, while in order at the same time to preserve their synchronism with the *Cyrena* brick-earths, as to show their anteriority to many of the gravels yielding Palæolithic implements that had been called indiscriminately "post-Glacial," we distinguished these Hessle beds, as "older post-Glacial." It is not a matter of much moment what names we select or accept for geological formations, so long as, by their use, confusion and misapprehension are avoided; but if we relegate these Hessle beds to the Glacial group, we abandon the age of deposits as the basis of their nomenclature, for the conditions under which they have been accumulated; and thus, to be consistent, we should term Glacial not only the deposits now going on in the Arctic regions, but even the beds forming in the Sound at Copenhagen, on the shores of which all our English cereals grow, for according to the authority quoted by Sir C. Lyell (Principles of Geology, 1872 edit., p. 383), a ship sunk at Copenhagen in 1807 is now almost buried in erratic blocks brought by the Baltic ice since that year.

I have confined my suggestions of probable synchronism between the Glacial features of North America and those of Britain mainly to English beds, because I have for several years urged that none of the Scotch beds can be older than the newer portion of the Upper Glacial, viz. the purple clay of Yorkshire where the chalk debris disappears, and the other chalkless clay to the north of it, which consist probably of morainic material left by the ice after it had receded from the lower ground of Yorkshire, overlain more or less by clay and other beds of Hessle age. Looking at the mountainous condition of Scotland, and that this part of Britain must have been that to which the ice of the major glaciation clung latest in its recession, it seems to me that all the earliest part of the morainic material which was coeval, not merely with the chalky clay of East Anglia, but even with all that in Holderness which contains any chalk debris, must lie out beyond the present coast-line of Scotland, and under the North Sea and Atlantic, having accumulated when the ice of that part of the Glacial period to whose recession it was due terminated beyond the present Scottish shores. When *Tellina obliqua* and *Nucula Cobboldiæ* have been found in the Scotch Glacial beds, there may be reason to regard the oldest part of the Scotch clay as coeval with that portion of the English Upper Glacial which Bridlington Cliff represents in the horizontal succession; but until these do so occur[1] I cannot see any reason for assigning an older date to the Scotch Till than above mentioned. Indeed it seems to me open to doubt whether much of it belongs to the period of the first or major glaciation, by reason of the improbability that beds of such character as glacial accumulations could have resisted the degrading action of any later ice. Such part only as by submergence during the minor glaciation was protected from the ice of that glaciation can, it seems to me, belong to what I term the Glacial period. The well-known case of Chapelhall in Lanarkshire appears to me to be an instance of this; for there the submergence of the Hessle period (which I have described as commencing in the South with the insignificant depth under which the Fen gravel accumulated, and increasing gradually northwards) having attained upwards of 500 feet, the sediment derived from the glaciers of the minor glaciation has been deposited over mollusca which lived upon the surface of the submerged (and so protected) moraine left by the recession of the ice of the major glaciation. The occurrence of Reindeer horns and some few other mammalian remains in Scotch beds, seems also to receive satisfactory explanation by reference to this minor glaciation.

Mr. Geikie, in the 2nd edition of his work, seems to feel the difficulty of earlier Glacial deposits having in Scotland escaped the

[1] Latitude can have nothing to do with the presence of these shells, because, among the derivative fossils of either late Crag, or early Glacial age, found by Mr. Jamieson in gravels capped by Boulder-clay, near Aberdeen, which he sent me for examination, there was an undoubted fragment of *Nucula Cobboldiæ*, showing that this species had once lived there; and *Tellina obliqua* has been found associated with the other Upper Crag *Tellens*, in beds in Iceland, whose fossils correspond with the later Crag beds. If, as I suspect, most of the ice-formed beds of Scotland belong to the minor glaciation, the ice of which destroyed the preceding beds as far as it extended, the derivative molluscan remains found by Mr. Jamieson probably constitute part of the wreck of the deposits of the first or major period of glaciation in that country.

destroying agency of the ice-sheet to which the Upper Glacial clay of East Anglia was due, and to be more inclined than he was to adopt the view of the later age generally of the Scotch beds; but he is not definite upon the subject, and still seems to regard the Scotch Till as including beds of all stages of the Glacial period. I am glad, however, to see that he is more disposed (as, for instance, in the case of the Wexford gravels[1]) than he was to allow molluscan evidence to have its weight in determining the age of Glacial deposits.

Mr. Geikie has thought it necessary to put a special erratum at the commencement of his second edition, that he finds Mr. Jeffreys stating in Phillips' Geology of Yorkshire, that instead of there being five of the Bridlington shells not known as living, all of them are identical with species found living in Arctic and Northern Seas. It should be known, therefore, that these identifications are not matters of recent discovery, such as from dredgings or otherwise, but matters of opinion upon which Mr. Jeffreys is not in accord with some of his fellow conchologists. That difference of opinion extends to a considerable number of the Pliocene mollusca, Mr. Jeffreys' method being to call any Pliocene shell which comes near to a species known living as identical with it, or at most a variety of it; but if afterwards something more closely resembling the fossil is discovered recent, then the former identification is abandoned, and the living species first called identical with or a variety of the fossil is separated from it, and the fossil form is allowed to stand as a good species, because it is found living. By pursuing through the Miocene and Eocene fauna, successively, this method of calling all Pliocene shells that approximate to living ones varieties of the latter, and these again varieties of their Miocene and Eocene predecessors, some astonishing results may be elaborated in the way of making a large per-centage of Eocene Mollusca identical with living species, contrary to the generally received opinion of geologists.

So slight, however, is the change which has taken place in shells during long periods, that many Eocene shells do not differ more from their nearest living analogues than do certain of these Bridlington ones; and if Mr. Jeffreys can point out any clear natural rule or law which will define where varietal difference ends, and specific difference begins, he will throw great light upon the study of living and fossil organisms, and cause evolutionists seriously to re-consider their views.

Two out of the five thus said by Mr. Jeffreys to be living are *Nucula Cobboldiæ* and *Tellina obliqua*. These shells abound together in the newer beds of the Crag, and in the East Anglian Glacial. Both are found at Bridlington; and one, the *Nucula*, in the centre of the 200 vertical feet of morainic clay of Dimlington in Holderness,[2] in such

[1] The Wexford gravels, *if* the fauna given from them be reliable, would also seem to be a remnant of the beds of the earlier glaciation in Ireland; for along with some other peculiar forms, a fragment of *Nucula Cobboldiæ* is mentioned by Forbes as having been found in them. It is, however, possible that this fragment might have been one of *Lucina* (*Loripes*) *divaricata*, a living British shell.

[2] The place is indicated on the accompanying map, where also the dotted line shows the position of the Chalk floor down to which, from contiguous borings, the chalky clay has been found to descend.

a position as to prove that it lived there. They appear to me to be conspicuously shells of the earlier part of the major glaciation, and they are absent from the Scotch[1] and all other English Glacial beds, as well as from all beds of post-Glacial age. The *Nucula* has been identified with more than one species living in the Pacific, apparently from conchologists not being acquainted with the full-grown Crag and Glacial shell; but from this full-grown shell the Pacific specimens differ widely.[2]

The *Tellina* is called by Mr. Jeffreys a variety of the peculiarly Glacial species *lata* (*calcarea* or *proxima*), which lives in Arctic seas, and characterizes the beds of the North-west of England and Scotland, and is found in East Anglian beds of Hessle age; but, unless he has met with it since I inquired of him a few years ago, he does not pretend that the shell itself (*i.e.* the variety as he calls it) exists in a living state. These two forms of *Tellina* (*lata* and *obliqua*), whether we call them varieties or species, lived *together* in all beds from those of the Red Crag to that of Bridlington; but, as far as yet known, the form *lata* is the only survivor of the two from the stage indicated by the Bridlington bed. Considering the great difficulties which beset the elucidation of Glacial formations, and how small is the assistance furnished by Palæontological evidence towards that elucidation, I am surprised that the facts concerning this *Nucula* and this *Tellina* have not met with more attention than they have hitherto done.

In conclusion, I beg, although I have dissented from some of his views, to tender Mr. Geikie my congratulations on the production of his able book—a work that will doubtless much extend the interest felt in the evidences of an age which, although the latest of geological periods, is, from its association with the history of Man in our latitudes, the most important of any.

P.S.—The whole of this paper having been in type before the November number of the Quarterly Journal of the Geological Society (No. 132) was issued, I was in ignorance of the tenor of the paper in that Journal by Mr. Mackintosh, on the sections around the estuary of the Dee; but having become acquainted several years ago with sections in that neighbourhood, as well as with the limits and distribution of the Upper Boulder-clay and Middle sand, I had then satisfied myself of, and suggested to geologists the identity of

[1] Except the derivative fragment found by Mr. Jamieson in the gravel near Aberdeen, referred to in a previous note on p. 26.

[2] Five living species of *Nucula* with divaricated markings like *Cobboldiæ* are known. They are confined to the Pacific Ocean, and have been described under the following names, viz. *N. mirabilis* (from Japan), *N. divaricata* (China Sea), *N. insignis* (Japan), *N. castrensis* (Sitka), and *N. Lyalli* (Vancouver). The first named is about one-third of the size of the full-grown *Cobboldiæ*, while none of the others exceed a ninth; and their hinge-teeth are from 4 to 9 fewer. The divaricated marks in all five extend to the margin of the shell, while *Cobboldiæ* has round this margin a broad belt which is free from them. It is possible, though hardly probable, that all the specimens yet obtained of these five species are those of young individuals which might have grown into a mature shell like *Cobboldiæ;* but until a specimen of the kind can be produced, it is as reasonable to identify any of these Pacific species with *Cobboldiæ*, as with the divaricated *Nuculæ* from the Gault.

those formations with the Hessle beds. The sections now given by Mr. Mackintosh may be advantageously compared with those of Holderness in the plate accompanying these pages, which was drawn by me in 1872. The limit in elevation of the upper clay in its marine form in Lancashire Mr. Mackintosh puts at 150 feet,[1] and he refers the accumulation of it to the same agency as that to which I refer the Hessle clay. The molluscan fauna of the upper clay, as well as of the middle sand and lower clay of the same region, has lately been described by Mr. Shone in a paper before the Geological Society; but as it is not yet published, I do not know what additions he may have made to those species from these beds which have at different times passed through my hands (and of which I have kept notes), or to the list given by Mr. T. M. Reade in vol. xxx. of the Quarterly Journal of the Geological Society, p. 30.[2] A comparison of them should be made with the list of species from the Hessle beds (Kelsea Hill, March, and Hunstanton) given in the tabular list to my father's Crag Mollusca Supplement in the volume of the Palæontographical Society for 1873, extended by a note at page 121 of the Quarterly Journal of the Geological Society, vol. xxxiii.; not forgetting, in the case of the shells of the middle sand and upper clay of the North-west, the probability of their having to a more or less extent been derived from the destruction of beds of Moel Tryfaen age. It will also be found, I think, that the middle sand of the Lancashire low ground has been confounded at high levels with sands of Moel Tryfaen age, which belong to the latest part of the Upper Glacial, as well as, possibly, with gravels of Kame origin, which, though they belong to the Hessle period, are of somewhat later date; having been formed by the subaerial melting of the glaciers of the Hessle period during the wane of the minor glaciation, and therefore either synchronous with, or posterior to, the upper clay.

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## III.—Across Europe and Asia.—Travelling Notes.

By Professor John Milne, F.G.S.;
Imperial College of Engineering, Tokei, Japan.

(Continued from Dec. II. Vol. IV. p. 568.)

### *VIII.—Lake Baikal to Kiachta and across Mongolia.*

Contents.—Lake Baikal to Kiachta—Description of route—Volcanic district near Povorotnaya—Volcanic district of the Tunka—Across Mongolia—Kiachta to Urga—Description of Mountains—Drift—Urga to Kalgan — Description of route—Granite Boulders—Volcanic Rocks.

About 5·30 p.m. on Thursday, 13th November, I said good-bye to Lake Baikal, and branched off upon a road to the right leading to Cabansk. Along this road, which was a very bad one, there was an apparently untouched forest of birch and pine, with here and there a clump of aspen. For some distance upon my left

[1] Mr. T. M. Reade, Quart. Journ. Geol. Soc., vol. xxx. p. 30, gives shells from apparently this clay (Brick clay) at 175 feet.

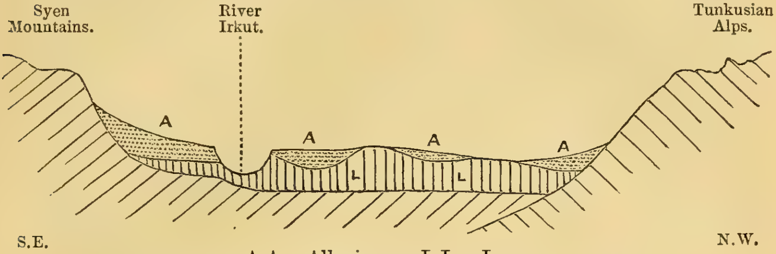
[2] This list, in so far as it refers to the occurrence in the Crag of species named in it, contains several inaccuracies.

extended a wide lake, which joined the Baikal. After much reckless driving across wide trackless plains, through gaps in ridges, snow drifts and clumps of trees, with a wild and drunken coachman, at half-past eight I found myself at the post station of Cabansk. After a windy and bitterly cold night, I was next morning at the station of Palavinsaya, the country round which is hilly and pretty. The next station was situated in a plain between sloping hills and isolated peaks. These hills being without wood, the country had an open appearance. As I went on, the snow, which I had been told in Irkutsk would be continuous as far as Kiachta, grew less and less, and at the station where I next changed horses, I had to abandon the sledge I had purchased and hire a carriage. Although the roads were now tolerably free from snow, the surrounding hills were still white with it. The next morning I passed the station of Povorotnaya. The soil now became sandy, and the only trees were pines. The way in which these were dotted about in clumps gave a park-like aspect to the district. In passing through a gap on the ridge of some hills which had been before me since leaving this last station, I came upon one of the most extensive views I had seen upon my journey. The country then before me was smooth and undulating in outline. Here and there small conical hills like old volcanos, the tops of which were sometimes capped with trees, stood up like islands above the plains of snow from which they rose. In and out between these I could see the track I had to take, trending away in the distance until it almost disappeared as a mere black line. From the little I saw of this country as I went rapidly rolling through it, it appeared to be a region of old volcanos, which would admirably bear comparison with Scrope's drawings of the Auvergne. Everywhere upon the road were black fragments of volcanic rocks, which were often vesicular and sometimes scoriaceous. To the right and to the left were small cones throwing shadows on the snow as even and distinct in their conical outline as the volcanos themselves. After crossing a small ridge beyond the station of Kalenishnaya, up a valley upon my left there was a large cone with a broken crater, down the sides of which the outline of an ancient stream of lava could be distinctly traced. At one or two places along the valley in which I travelled there were some large fissures extending down from the mountains. These were generally ten to twelve feet in depth, and from twenty to forty feet in width. In some places they intersected the road and had to be crossed by a bridge. These openings showed sections of a greyish sandy soil, which may be regarded as an alluvial covering to the volcanic rocks beneath.

The volcanic rocks of the Tunka district, to which I have before several times referred, hold a somewhat similar position to the alluvial beds which cap them.

The serrated outlines of the mountains which bound this last-mentioned district, I saw on my way down the Baikal, and I also mentioned them as being visible from Irkutsk. A general idea of the situation of these rocks may be gathered from the annexed section, which I have drawn from a description given to me by M. Tchersky, who had paid a visit to the Tunka valley.

This section runs from S.E. to N.W. across the valley of the River Irkut, from the Syen Mountains to the Tunkusian Alps. These latter are made up of limestones and pyroxenic rocks which are much metamorphosed. All that is known about them at present is,




A,A, = Alluvium. L,L, = Lava.
Diagram section of the Irkut Valley (after M. Tchersky).

that they are older than the Jura sandstones, beneath which they are seen to pass. In the valley between these two ranges of mountains there are beds of lava and of alluvium. This, like that on the road to Kiachta, is basaltic in character. I often inquired about felspathic lavas, but I never heard of them. The colour of this lava is black, or some shade of black or bluish black, and occasionally grey. It is generally compact. When it is scoriaceous, it sometimes has a reddish-grey colour. Many of the specimens which I saw contained much olivine. In some places, as near Tunka, there are small hills of lava. These were at first thought to be old craters, but are now only supposed to mark the places where the lava may have welled up through fissures. The beds of lava are not the result of one flow, but of several. This may be seen at several points where there is evidence of one bed of lava having flowed, become cool and scoriaceous in its surface, before a bed which may be seen lying upon it ever issued from the crater. In some places as many as six beds may be seen lying one upon the other, each compact at its base, but gradually merging into a scoriaceous character above. At one locality M. Tchersky described to me instances of the peculiar concentric structure which the lava had assumed.

From the evidence we have, the outburst of the Tunkusian volcanos must have extended over a long period of time, apparently having commenced before the excavation of the Tunka valley, which they partly filled with their products. The next step was the wearing away of these lavas into hollows, and into these an alluvium, probably identical with that which now covers a great portion of Siberia, was deposited. That this deposition was general in its nature is evident from the corresponding position of similar beds in neighbouring depressions. At the base of the alluvium there are rounded pebbles of basalt derived from the rocks beneath. In these deposits Mammalian remains such as of the Mammoth and Rhinoceros have been found. Some of these beds are found as much as 1157 feet above the village of Tunka, which is itself at a considerable height above the Baikal, and therefore at still greater height above the level of the sea.

This would bring these deposits of Siberian alluvium almost, if not quite, upon a level with any that have been deposited upon the Mongolian plateau, about which I shall speak presently, both of them indicating a great depression of land beneath water that was in all probability fresh in recent times. Up this same valley there are some beds of unstratified alluvium, in which there are buried angular blocks of rock not belonging to the district in which they are found. Although I made all inquiries I could about these, their discoverer, M. Tchersky, did not lead me to understand that they afforded evidence of glacial origin. Nevertheless, further observations may show them to have been derived, perhaps, from local glaciers. If this is so, then we have a fragment of the evidence that is needed to establish the fact that this portion of Siberia was once invaded by ice. When this is adduced, the origin of the earlier deposits of the Siberian drift may be explained in a manner different to that which I have suggested.

On the same afternoon that I passed through the volcanic district of Kalenishnaya, I met one or two tea caravans. The flat faces and oblique eyes of the men who drove these told me my European associations must soon end, and I should be very shortly among the Mongols. That night I reached Troitskosarsk. This town lies near the head of a sloping valley, bounded on either side by hills of a moderate height. About two miles from this, down the valley, is Kiachta, the Russian frontier town, which immediately abuts on the palisaded Chinese town of Miamachin. These three towns are better known and spoken of under the name of Kiachta, which is the smallest of the three. It is seldom that there is sufficient snow about Kiachta to enable sledges to be used; however, there was quite enough upon the surrounding hills to prevent me from ascending them. In the valley there are beds of an earthy sand, through which, in places, I saw sections twenty feet in thickness, cut by a small stream which flows down through them towards the Selinga. The wearing away of this sandy covering gives the arenaceous character to the soil of the neighbourhood, which is so striking to all visitors.

At Kiachta I was delayed several days before I could complete my arrangements for crossing Mongolia, which was now before me. My intention had been to travel with a Russian officer whose acquaintance I had made in Irkutsk. In Kiachta my intentions were frustrated by the Commissary of the Frontier showing me that as my friend was to travel as a courier by a special route, it was not permissible to allow me to proceed by the same road, without violating arrangements entered into between the Russian and Chinese Governments respecting couriers and the routes they travel. Disappointed in this, I next made arrangements to accompany some Mongols who were conducting a caravan as far as Changiakau or Kalgan, the frontier town between China and Mongolia. I had five camels for myself, my baggage, and a Cossack, whom the Commissary very kindly allowed to conduct me as far as Pekin.

It was the 9th of December before I started. After passing Miamachin, which I may remark is the cleanest town in China, we were soon in the open country and upon a sandy tract between low smooth hills. Towards evening we entered a flattish plain, after crossing which we were again among some hills. Owing to the slipperiness of the road, we had great difficulty in getting our camels up the steeper slopes. It was now bitterly cold, the temperature varying between —18° and —21° R.; sometimes it was rather less, and often more. During this portion of our journey we took advantage of the moonlight nights. Starting at 10 A.M. we generally travelled continuously until 7 or 8 P.M., when we rested half an hour for tea, after which we continued until 2 A.M. before finally resting for the night.

On the morning of the 11th we passed near the valley of the River Sharinkol, where there were some fir-trees on the hills, and in the afternoon we passed along a valley bounded on either side by a series of low peaks. The only birds we saw were ravens, magpies, a small finch, and some sparrows. We met with the former of these along the whole of our route across the desert. They were very bold, and in spite of our best endeavours they continually settled on the backs of our camels, to tear open the provision bags.

At many points along this portion of the route the growth of trees upon the northern slope of the hills, while the southern side was barren, was very noticeable. As a consequence of this, these southern slopes, being destitute of any covering which could prevent the percolating water and other denuding agencies from carrying material away, were steep and scarp-like; whilst the northern slopes, with their protective covering of vegetation, were more gentle in their inclination.

It might of course be argued that it was the gentle slope which produced the trees; but I hardly think that this could have been the case, as I saw examples of gentle slopes towards the south which were as equally destitute of any covering as the steeper ones. In many of the valleys I saw sections of a sandy drift something like that around Kiachta, which must in certain cases have been more than forty feet in thickness. In the upper parts of this I observed many fragments of granitic rocks.

On the night of the 11th, about 12 P.M. we entered a steep pass called the Makatah, and it was not until 2 P.M. next day, after 27 hours of continuous travelling, that we could consider ourselves to be fairly through it.

At about midnight on the 13th Dec. we crossed the Olindowa Pass, and at 7 A.M. the Gutinawa Pass, reaching Urga on the afternoon of the same day. The approach to the town is down a broad flat valley, bounded on either side by steep hills. At right angles to the end of this valley there is a high range of hills, beneath which, at the confluence, so to speak, of three openings in the range Urga is situated.

Up to this point, all that I saw were a few granitic rocks, and a considerable covering of alluvium.

I left this religious Mongolian centre, which is the residence of a living Budda, on Thursday the 16th of December. The valley by which I made my exit was to the left, and at right angles to the one by which I had entered. It was about three-quarters of a mile broad, and was covered with large boulders and rounded stones. Some of these were granite, others sandstones, and others, I think, were limestone. There were also some chloritic crystalline rocks like greenstone. Not long after leaving Urga, we led our camels over the frozen waters of the River Tola, which was apparently made up of two streams, each about twenty yards in breadth. On some of the hills, where steep scarps prevented an accumulation of snow, red-coloured stratified rocks dipping towards the south were visible. Before the end of the next day the trees, which had been gradually becoming scarcer, entirely disappeared. With this disappearance, the magpies, which had thus far accompanied us, also disappeared, and all that we had left as companions were large black ravens. The country was hilly, but smooth in outline, until the morning of the 19th, when we entered a large plain, which was brown with grass cropping up through a thin covering of snow. The hills surrounding this plain, which was typical of the country for several succeeding days, although not high, were very rugged. On examination I found them to be made up of black, and in some few cases reddish rocks of volcanic origin, which were apparently basaltic. Where the snow had been blown away by the wind, or worn away by traffic, I often saw large quantities of agate, jasper, and chalcedony, resulting from the decomposition of the amygdaloidal portions of this rock. On the 22nd we reached a village called Teck-sha-buinta, where I narrowly escaped hostilities. The country beyond this was very similar to that which I had just been traversing. Most of the hills were low and undulating, but some few rose to heights of about 400 feet, and had ragged summits. In addition to the black basaltic rocks, there were now some pinkish porphyritic felsites. Some of these were phonolitic, giving out a clear ringing sound when struck. The ground was everywhere perforated by the burrows of small marmots (*Lagomys Ogotono*). There were also a few hares (*Lepus Tolai*), a few large kites, and ravens, and two or three finches to be seen. These, with a few antelopes (*Antilope gutturosa*), and an occasional partridge (*Perdix barbata*), constituted the desert life.

Through some of our camels suffering with sore feet, I was delayed for two days at a place called Kooistilroi, where there were two or three felt tents or yourts, the head-quarters of a Mongolian Mandarin. I left this place on the 25th December. On the evening of the same day, near our first camping place, I saw some large boulders of granite. These were lying on the surface of the ground, and, I think, must have been produced by disintegration from the rocks on which they rested. All next day the country through which we passed was granite, and there were so many boulders lying about, that during the night it was necessary to have a lantern in order to steer safely through them. On the 28th these boulders were so numerous that they formed quite a rockery like feature in the landscape.

On the 4th of January the character of the country changed, and it now looked as if the whole surface of the ground had been cut up into earthworks for purposes of fortification. Instead of the gritty remains of a degraded granite, we now had much red sand.

At 11 A.M. next day we sighted mountains before us. From the fragments of rock strewn about in the pass leading through them, they probably consisted of granite and greenish porphyry. The place at which we crossed was called Haita, and the mountains, I believe, the Ugundui Mountains. At this point magpies again appeared. The rest of our road was mostly over rolling plains, with here and there a ridge. By daybreak on the morning of the 9th of January I was leaving the Mongolian plains, and was descending a steep and rocky pass towards Kalgan, which was then almost beneath my feet, there being on all sides of me rocks of unmistakably volcanic origin.

While on this portion of my journey, which lasted 31 days, the thermometer registered from 0° to —24° R. The ground was almost everywhere covered with snow, which we had to scrape away whenever we wished to pitch our tent. This was generally about 3 P.M., when we rested until 9 P.M., the remainder of the 24 hours being spent in continuous travelling, time not being allowed even for food. I had only one opportunity to take off any of my clothes, and that was at Urga, where I also had a wash. This latter action I repeated three times when the thermometer rose to —10° R. My time was chiefly spent in trying to thaw food for myself over a small fire of camel's dung, or else in endeavouring to keep warm. These circumstances, together with the fact that I was so bundled in skins, that it was with difficulty I could walk, will, in part, account for the meagreness of my observations along this section of my journey, and the only reason that I now venture to offer them is, that so little is known of this portion of the world.

*Conclusion.*—This portion of Mongolia lying between Kiachta and Kalgan, according to the measurements of MM. Fuss and V. Bunge, and later Fritsche, would appear as a saucer-shaped plateau, the outer edges of which are about 5000 feet above sea-level, while the inner central part is only from 2000 to 2400 feet. The ascent to this table-land is gentle and by a series of undulations upon the northern side, while on the southern side it is precipitous and by a single pass. The inner parts of this saucer, which is more elliptical than circular in form, slope gently towards a level central area. The whole of this shallow basin is traversed at intervals by low mountains and rounded hills. From what I saw it would appear as if volcanic rocks formed the predominating geological feature of the country. These in the northern parts were more or less basaltic and very often amygdaloidal. The amygdules of these rocks were filled with some siliceous mineral like quartz, and this, I may add, generally had a coating of a chloritic mineral interposed between it and the sides of the cavity in which it rested. In the more southern parts of the volcanic districts the rocks appeared to be more felsitic in their character. Some of these were markedly porphyritic, while at Koorstelroi they were phonolitic. The rocks which form the lower edge of the plateau near Kalgan are described by Pumpelly as being porphyritic felsites. Those which I saw in the upper portions of the pass at this point differed from those lower down; while the upper ones were amygdaloidal and somewhat basaltic in appearance, the lower ones were felsitic. Where these volcanic rocks occurred, they generally stood up above the surrounding country as hard rough ridges. When they were elevated and brought to view by refractive agencies producing the Fata Morgana, which was a common phenomenon while travelling in the desert, they appeared as rugged islands floating on a level silvery sea. The other rocks which I saw were chiefly granitic. The first of these occurred as boulders which I half suspected had been transported by the action of ice. This I afterwards found not to be the case, as I shortly afterwards (Dec. 28th) came upon a district where, by the ordinary processes of degradation, these boulders were being weathered out from their parent rock. In this district, through the disintegration of the granite, the road was very gritty and the ground hard. Apparently as a consequence of this, there was an absence of the small burrowing pika, which before had been visible at every point along the road. The buzzard, which feeds upon the pika, was naturally absent also. Not only would the geological nature of the district in this way affect the animals, but it would also have an important influence upon the plants.

In one place, on the 31st December, I noticed a syenitic rock. Besides these volcanic and granitic rocks, there was the covering of sandy drift. In the Kalgan Pass this had the appearance of a reddish and sometimes whitish marl. As to whether the marls and sands of the Gobi plateau have any connexion with similar deposits in Siberia, I should be afraid to say before further evidence can be adduced, all that I can do being to refer to what I said about the high levels of the terrace deposits in the valley of the Tunka.

Mr. Pumpelly, who traversed this same region in 1864, at a similar season of the year as that at which I crossed it, was more fortunate in his observations, this being partly due to his having taken a somewhat different route.

Starting from Kalgan at Lake Bilika Noor, he found horizontally stratified—1. Yellowish grey limestone; 2. Thin beds of clay or earth with manganese concretions; 3. Bed of crystalline gypsum; 4. Gypsum with red clay. The last mentioned being the oldest or lowest in the series. This was before reaching the Mingan Hills, where quartzite, compact sandstone, and a talco-argillaceous schist, dipping at a high angle towards the N.E., were found. Beyond this, beds of limestone were met dipping S.S.W. Still further on the road, a white calcareous sandstone, with thin beds of an interstratified arenaceous limestone, was observed. Sandstone was next found, and then granite, until the valley of the Ulanoor was reached, where clayslate was met with, and afterwards more granite.

Beyond this, at the hills of Senji, micaceous, argillaceous, and talcose schists, traversed with dykes of greenstone, were seen. Beyond these hills, after eleven days' journey since leaving Kalgan, basalt was met with, which rose in cones from 100 to 150 feet in height. After this, calcareous sandstone, conglomerate and limestone were met with, which were followed by more granite, mica-schist, and dolomite.

On the 15th day of travel, trachytic porphyry was met with. On the 16th day, granitic and syenitic rocks. On the 21st day, just before reaching Urga, hills of a black metamorphosed slate were seen. These, together with the Steppe deposits of alluvial material, appear to have been the chief geological points which were observed.

Placing my fragmentary gleanings along with the notes collected by Mr. Pumpelly, it would appear that there is considerable geological variety to be found upon the Mongolian plateau, which is usually pictured as a sandy waste, known under the name of the Desert of Gobi or Shamo.

The younger formations of this area apparently give evidence of a large sheet of water having at one time covered this portion of the globe, which in itself probably implies enormous subsidence. Such vast changes in the relation of land and water in this portion of the globe, if they can be really shown to have occurred, would at once give some clue to the climate of past time, the distribution of faunas, and other like phenomena, which are not only interesting as facts in the history of our globe, but which also have a practical bearing upon our present welfare.

Then there are the volcanos. These, I believe, from what I learnt from M. Paderin, Acting Russian Consul at Urga, who had recently made a visit to Ulisaitai, and from what I learnt from other sources, must have covered an area as large and perhaps larger than any other volcanic district with which we are acquainted. In the mountains of Manchuria the flickering embers of these fiery outbursts appear to have continued down to historic times, and no doubt, as Mr. Pumpelly remarks, the violent earthquakes which shake the districts of North Chihli, and which I have described as of continual occurrence round Lake Baikal, are remnants of this action.

Altogether Mongolia is an interesting region, and one which would repay the geologist who could visit it at a favourable season.

Note.—See Geological Researches in China, Mongolia, and Japan, by Raphael Pumpelly. Smithsonian Contributions to Knowledge. No. 202.

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

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## IV.—Palæolithic Implements from the Valley of the Axe.

By W. S. M. D'Urban, F.L.S.,
Curator of the Devon and Exeter Albert Memorial Museum, Exeter.

At Broom, in the parish of Hawkchurch, near Axminster, close to the River Axe, in the angle formed by the junction of a tributary brook with it, is a low hill, the summit of which is about 50 feet above the level of the rails of the London and South-Western Railway, which runs at its base. This hill consists of a mass of chert gravel intermingled with ferruginous clay of a yellow colour, and interstratified with seams of sandy clay, without shells or other animal-remains, as far as is at present known. There are a few much-rolled pebbles of quartz; of a hard dark-grey siliceous rock; and of chalk flints, mingled with the chert fragments, many of which are angular or subangular. It has been cut into for ballast for the railway, and about half has been removed in the last fifteen years, exposing a section of from 40 to 50 feet in depth. The bottom of the pit is on a level with the rails, which are a few feet above the river, and about 150 feet above the level of the sea, about six miles distant. The chert gravel was probably derived from the Greensand which caps the hills inclosing the valley.

In this gravel during the present year have been found numerous implements of the usual Palæolithic forms, made of very dark brown chert. Some of them have been much rolled, but the majority are quite sharp and uninjured. Many have been picked up on the railway after the gravel has been used for ballasting the line. It is unfortunate that none have been found *in sitû* by any one except the workmen, but from the nature of the gravel it is very difficult to distinguish them from the surrounding mass, until they have been washed clean by the rain. Some have been deposited in the Blackmore Museum at Salisbury, and a large number have been secured for the Albert Memorial Museum at Exeter.

Note.—We have been favoured by Mr. W. S. M. D'Urban with a set of three photographs, 8vo. size, containing admirable reproductions of the forms of 36 of these Palæolithic chert implements from the River-drift Gravel of the Valley of the Axe—now preserved in the Exeter Museum. They convey an excellent idea of the form of these unpolished implements, which remind one of the elliptical form of River-drift implements from Icklingham, and others of the acutely-pointed and ovate-pointed flint-implements from River-drift, Hoxne, Norfolk, figured in the Geol. Mag. 1873, Vol. X. pp. 4-10, Plates I. and II., copied from "Ancient Stone Implements, etc., of Great Britain;" by John Evans, D.C.L., F.R.S., V.P.G.S., 1872, 8vo. (see Fig. 421, p. 490, Fig. 449, p. 519, and Fig. 450, p. 520). Mr. D'Urban informs us that "copies of these photographs may be obtained at 1*s.* 6*d.* each, or 4*s.* 6*d.* the set, which is cost price."—Edit. Geol. Mag.

## REVIEWS.

Céphalopodes. Etudes Générales; Extraits du Système Silurien du Centre de la Bohême. Par Joachim Barrande. 8vo. pp. 253, 4 plates and several tables. (Prague, 1877.)

In this memoir M. Barrande gives us a most interesting, and instructive, summary of his valuable researches on the embryology, organization, distribution and range of the Palæozoic Cephalopods, with additional notes on the Secondary, Tertiary, and existing species. The greater part of his observations are, however, founded on an examination of the Bohemian forms, 1127 in number, or nearly one-half of the known species from the ancient rocks of the two continents. The specimens are said to occur very abundantly, and in a good state of preservation, often affording evidence of the internal structure. After a critical analysis of the distribution of the order in time, and a rigid investigation of the origin and growth of the shell in the *Nautilidæ,* M. Barrande feels a positive conviction that no facts favourable to the theory of Evolution, or descent by modification, can possibly be derived from a systematic study of the Cephalopoda.

In a review of the Embryological literature of the subject, it is mentioned that Dr. Robert Hooke was the first to call attention (in a paper read before the Royal Society of London in 1696), to the initial development of the shell in *Nautilus,* and the value of the publications of Prof. Phillips, MM. de Koninck, Franz Hauer, Alph. Hyatt, F. and G. Sandberger, etc., etc., in the present century, is duly acknowledged. It appears from their researches, and those of M. Barrande, that there exists a most important radical difference between the early stages of the development of the families *Ammonitidæ* and *Goniatidæ,* as compared with that of the *Nautilidæ,* an ovisac being always present in the former, and absent in the latter. This fact alone is considered by M. Barrande as sufficient evidence of the non-derivation of the *Ammonites,* and *Goniatites* from the primitive *Nautilidæ,* for, it is urged, if a correspondence in the embryonic characters of diverse genera be regarded as proof of their descent by modification from some common ancestor, it must necessarily follow that so marked a contrast is a sure indication of an independent origin. Again, it is contended that the embryonic type of the primitive *Nautilidæ* persists unchanged up to the present time, while that of the families *Goniatidæ,* and *Ammonitidæ,* appears suddenly, and retains its distinctive characters until the final extinction of all the genera of which they are composed. Moreover, an examination both of the external and internal structure of the Cephalopods, whether as considered with regard to the position and diameter of the syphon, or the size, curvature, ornamentation, and composition of the shell, absolutely fails to furnish any evidence of progressive development, but shows, on the contrary, that any variation in these characters had no effect whatever, either upon the number of a species, or the vertical range of a genus. For instance, M. Barrande observes that although the *Nautilidæ* possessed of a compound opening might be looked upon as more highly organized than those with a simple one, yet both these forms were simultaneously represented in the lowest beds of the second Silurian zone, the simpler forms also were specifically far more numerous, and endowed with a much greater power of vitality. Thus, as the accompanying Table shows, five out of the six compound types were restricted to the Silurian rocks, one only ranged up to the Carboniferous, while, of the 12 simpler forms, but six died out at the close of the Silurian, the straight-shelled *Orthoceras* living on to the Trias, and the whorled *Nautilus* persisting even to the recent period. The evidence of the few admitted intermediary forms is also regarded as invalid, on account of the anachronism in-

TABLE SHOWING THE VERTICAL DISTRIBUTION OF THE *NAUTILIDÆ*, *ASCOCERATIDÆ*, AND *GONIATIDÆ*; THE PRIMITIVE TYPES, AND THEIR GEOGRAPHICAL RANGE, ETC., ETC. (AFTER BARRANDE).

| 1 | 2 | 3 | 4 FORMATIONS. 4 | | | | | | | | | | | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| p. 125. | p. 84 & 128. | p. 84. | p. 84. Palæozoic. | | | | | | Mesozoic | | | Cainozoic. | | p. 125. | p. 125. | p. 28. | p. 64 |
| Primitive Types. | Genera and Sub-Genera.[1] | No. of Paleozoic Species. | Silurian. | | | D. | C. | P. | T. | L. J. | C. | T. | R. | Geological Horizons of the 12 Primitive Types appearing in the lowest beds of the Second Silurian Zone. | Numerical, specific, and geographical distribution of the 12 Primitive Types appearing in the lowest beds of the Second Silurian Zone.[6] | No. of sp. in which the Embryological characters have been observed. Nautilidæ. No Ovisac. | Goniatidæ. Ovisac. |
| | | | I. | II. | III. | | | | | | | | | | | | |
| | Fam. NAUTILIDÆ. | | | | | | | | | | | | | | | | |
| | Types with a simple Opening. | | | | | | | | | | | | | | | | |
| * | *TROCHOCERAS*, Barr., Hall. | 64 | | 1 | 61 | 2 | | | | | | | | . . . . . | 1 Newfoundland. | 2 | |
| * | *NAUTILUS*, Linné. | 119 | | 12 | 10 | 8 | 84 | 5 | 47 | 47 | 63 | 15 | 3 | Calciferous Sandstone. | 2 Newfoundld, 2 Canada. | 37 | |
| | s.g. *Aturia*, Bronn.[2] | | | | | | | | | | | 4 | | | | 1 | |
| | *GYROCERAS*, Konck. | 39 | | | 16 | 17 | 6 | | | | | | | | | 2 | |
| * | s.g. *Discoceras*, Barr. | 3 | | 3 | | - | | | | | | | | Orthoceras Limestone. | 2 Norway, 1 Russia. | | |
| * | *CYRTOCERAS*, Goldf. | 475 | | 90 | 299 | 59 | 26 | 1 | | | | | | Orthoceras Limestone, Tremadoc. | 1 England, 1 Norway, 2 Sweden, 14 Russia. | 29 | |
| * | s.g. *Piloceras*, Salt. | 6 | | 6 | | | | | | | | | | Calciferous Limestone, L. Llandeilo. | 1 Canada, 4 Newfoundland, 2 Scotland. | | |
| * | *ORTHOCERAS*, Breyn. | 1132 Trias 14 | | 260 | 626 | 131 | 112 | 3 | 14 | | | | | Calciferous Sandstone, L. Llandeilo, Orthoceras Limestone, Band *d*1. (Barrande). | 1 Newfoundland, 14 Canada, 2 New York, 1 Wisconsin, 3 Missouri, 6 England, 9 Norway, 6 Sweden, 24 Russia, 17 Bohemia. | 25 | |
| * | s.g. *ENDOCERAS*,[3] Hall. | 46 | | 46 | | | | | | | | | | Calciferous Sandstone, L. Llandeilo, Orthoceras Limest., Band *d*1. Barr. | 1 Canada, 1 England, 8 Russia, 3 Sweden, 2 Norway, 3 Bohemia. | 1 | |
| | s.g. *Gonioceras*, Hall. | 2 | | 2 | | | | | | | | | | | | | |
| | s.g. *Huronia*, Stokes. | 8 | | | 8 | | | | | | | | | | | | |
| ? | *Tretoceras*, Salt. | 3 | | 2 | 1 | | | | | | | | | ? | | | |

| 1 | 2 | 3 | 4 | | | | | | | | | | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Types with a Compound Opening | | | | | | | | | | | | | | | |
| | *Adelphoceras*, Barr. | 2 | | 2 | | | | | | | | | | | | |
| | *Hercoceras*, Barr. | 2 | | 2 | | | | | | | | | | | 1 | |
| * | *LITUITES*, Breyn. | 23 | 22 | 1 | | | | | | | | | Orthoceras Limst., Calciferous Sandst., Band *d*1. | 4 Canada, 4 Norway, 4 Sweden, 9 Russia, 1 Bohemia. | 2 | |
| * | *s.g. Ophidioceras*, Barr. | 8 | 2 | 6 | | | | | | | | | Orthoceras Limestone. | 1 Norway, 1 Russia. | 3 | |
| | *PHRAGMOCERAS*, Brod. | 51 | 2 | 49 | | | | | | | | | | | 4 | |
| * | *GOMPHOCERAS*, Sow. | 110 | 5 | 87 | 14 | ? 4 | | | | | | | Orthoceras Limestone. | 1 Russia. | 2 | |
| | Heterogeneous Types. | | | | | | | | | | | | | | | |
| | *Nothoceras*, Barr. | 1 | | 1 | | | | | | | | | | | | |
| * | *Bathmoceras*, Barr. = *Conoceras*, Bronn. | 4 | 4 | | | | | | | | | | Orthoceras Limest., Band *d*1. | 2 Bohemia, 1 Sweden. | | |
| | *Mesoceras*, Barr. | 1 | | 1 | | | | | | | | | | | | |
| | Fam. Ascoceratidæ. | | | | | | | | | | | | | | | |
| | *ASCOCERAS* = *APHRAGMITES*, Barr. | 16 | 4 | 12 | | | | | | | | | | | | |
| | *Glossoceras*, Barr. | 3 | | 3 | | | | | | | | | | | | |
| | Fam. Goniatidæ. | | | | | | | | | | | | | | | |
| * | *BACTRITES*, Sandb. | 13 | 2 | | 11 | | | 2 | | | | | Orthoceras Limest., Band *d*1. | 1 Russia, 1 Bohemia. | | 1 |
| | [4] *GONIATITES*, de Haan. | 320 | | 17 | 180 | 123 | | | | | | | | | | 13 |
| | *s.g. Clymenia*, Münster. | 37 | | | 37 | | | | | | | | | | | |
| 12 | Total for three Families | 2487 | 463 | 1202 | 459 | 355 | 9 | 63 | 47 | 63 | 19 | 3 | | Total 164 sp. | 109 | 14 |
| | Lituites ? not included[5] | 20 | | | | | | | | | | | | Ammonitidæ | ..... | 7 |
| | | 2507 | | | | | | | | | | | Total of sp. in which the Embryological characters have been satisfactorily determined ..... ..... ..... | | 130 | |

[1] The 12 Principal or Cosmopolitan genera are printed in large type. The 14 Local, or Secondary, in italics. [2] *s.g.* sub-genus.

* An * prefixed distinguishes the 12 Primitive types which make their simultaneous appearance in the lowest beds of Barrande's Second Silurian zone = L.S.

[3] *Endoceras*, though restricted to the Second Silurian zone, is classed with the Principal genera on account of its extended geographical range.

[4] The Goniatites from the Trias of St. Cassian are not included, as Dr. Gust. Laube considers they should be removed from that genus.

[5] 26 Genera and Sub-Genera: 12 Principal, 14 Secondary.

[6] Those countries are alone enumerated in which the lowest beds of the Second Silurian zone are positively known to occur.

volved in their first appearance *after* the genera which they might, otherwise, be supposed to connect.

The author is also of opinion, that the simultaneous occurrence of twelve primitive, cosmopolitan types at the base of the second Silurian zone (=L.S.) is absolute proof of their independent origin. It must, however, be noted that the assumed absence of all Cephalopods and Acephala in the primiordial zone rests solely on negative evidence, and testimony of that nature is subject to continual modification, of which the long controverted existence of fishes in the Upper Silurian rocks and of Mammalia in the Purbecks may serve as examples. It is probable, also, that Evolutionists will be inclined to regard the wide distribution of the so-termed primitive types as indicating their antiquity, and they will not, therefore, share M. Barrande's ideas as to the utter impossibility of the discovery of a centre of development in some of the unexplored Cambrian areas. It may be added that in the Lower Tremadoc rocks of St. Davids, in South Wales (now classed on palæontological grounds as Upper Cambrian), Mr. Henry Hicks has already recorded the presence of one species of *Orthoceras* and twelve of *Lamellibranchiata.*

In concluding his investigations M. Barrande alludes in eulogistic terms to the admirable memoir by Mr. Thomas Davidson[1] on "What is a Brachiopod?" He refers, likewise, to the publications of M. Grand'Eury on the Carboniferous flora of Central France, and to the views expressed by Mr. Carruthers in his address to the Geologists' Association,[2] as being in complete accordance with the results of his own researches, and thus considers it manifest that no support to the theory of Evolution can be derived either from the Vegetable Kingdom, or from the Brachiopoda, Crustacea, and Cephalopoda in the animal domain.

The foregoing Table (pp. 40–41), compiled from five of the author's, indicates the chief points of his classification, the geological, and geographical horizons of the primitive types, the vertical distribution of the families *Nautilidæ, Ascoceratidæ,* and *Goniatidæ,* and the number of species of each genus in which the embryological characters have been satisfactorily determined.[3] A.C.

## REPORTS AND PROCEEDINGS.

Geological Society of London.—I.—Nov. 21, 1877.—John Evans, Esq., F.R.S., D.C.L., Vice-President, in the Chair.—The following communications were read:—

1. "On the Glacial Deposits of West Cheshire, together with Lists of the Fauna found in the Drift of Cheshire and adjoining Counties." By W. Shone, Esq., F.G.S.

The conclusions arrived at by the author in this paper were as

[1] Geol. Mag., April, May, June, 1877. [2] Geol. Mag., Dec. 1876.

[3] For a previous review of M. Barrande's labours on Cephalopoda, see Geol. Mag. 1870, Vol. VII. p. 486.

follows :—Like Prof. Hull, he distinguished a triple division of the deposits under consideration. 1. The Lower Boulder-clay, or, as he preferred to call it, Lower Glacial Drift, resting immediately upon the eroded surface of the Keuper, consists for the most part of compact clay, containing numerous and large striated erratics, together with a fauna of Scandinavian type, the Gasteropoda being generally filled with fine silt containing Microzoa. The author believed that the shells found in this deposit were principally distributed by ground-ice, which took them up and floated them off the shore. 2. The Middle Sands and Gravels, or Interglacial Drift of the author, consist chiefly of sands and gravels containing few (if any) glaciated stones. The fauna of this division is Celtic, with a few Scandinavian species derived from the Lower Boulder-clay; the shells were distributed principally by currents; and the Gasteropoda seldom, if ever, filled with sand containing Microzoa. 3. The Upper Boulder-clay or Upper Glacial Drift, is composed for the most part of clay not so compact as the Lower Boulder-clay, and containing fewer and smaller glaciated stones, which are more abundant near the base. The fauna is Scandinavian at the base of the beds. The shells were distributed principally by ground-ice, and those of southern type derived from the Middle Sands and Gravels. The Gasteropoda are chiefly filled with silt containing Microzoa. The paper was accompanied by lists and tables of fossils, a large collection of which was exhibited in illustration of the paper.

2. "The Moffat Series." By C. Lapworth, Esq., F.G.S.

The fossils found in the highly convoluted Lower Silurian rocks of the southern uplands of Scotland are usually restricted to certain narrow bands of black carbonaceous and Graptolitic shales, which, from their especial abundance in the neighbourhood of the town of Moffat, Dumfriesshire, are known to geologists as the Moffat Shales or Moffat Series.

The most perfect section of the black shales visible within the Moffat area is exhibited in the cliffs of the gorge of Dobb's Linn, at the head of Moffatdale. It was shown by the author that they are here disposed in a broken and partially inverted anticlinal, which throws off on both sides the basal beds of the surrounding non-fossiliferous greywackes. They are distinctly arranged in three successive groups or divisions. Each of these divisions is distinguished by special lithological characteristics, and possesses a distinct fauna. To the lower and middle divisions a few fossils are common, but between the middle and upper divisions the palæontological break is complete. These divisions, again, are naturally subdivided into several zones, each characterized by special species, or groups of species.

A larger exposure of the same deposits occurs at Craigmichan, a few miles to the south-west, where the beds of the lower division are shown to a much greater depth than at Dobb's Linn. In these two localities the general succession of the Graptolitic shales is as follows :—

| | | | Feet. |
|---|---|---|---|
| (*c*) *Birkhill Shales*, or Upper Moffat. | (*b*) Upper Birkhill | Grey and purple flagstones, with lines of black and white shale ..... | 70 to 80 |
| | (*a*) Lower Birkhill | Black pyritous shales, with seams of brightly coloured clays ............. | 60 to 70 |
| (*b*) *Hartfell Shales*, or Middle Moffat | (*b*) Upper Hartfell | Pale grey or green non-fossiliferous mudstones ........................................ | 45 |
| | (*a*) Lower Hartfell | Black hard slaty shales and flags ..... | 40 to 50 |
| (*a*) *Glenkiln Shales*, or Lower Moffat. | | Yellow and grey shales and flags, non-fossiliferous, with a few bands of soft black Graptolitic shales ........................................................ | 150 |

With the aid afforded by these sections, the thorough investigation of the ten subparallel black shale-bands of the Moffat area is rendered a matter of ease and certainty. Of these, the four bands lying to the south-west of Saint Mary's Loch are the most continuous. They were described in detail by the author, and it was shown that in each the only strata apparent are indisputably those of the type-sections of Dobb's Linn and Craigmichan, with which they agree zone for zone in sequence and in all their characters, mineralogical and zoological. Here, also, the beds are arranged in greatly elongated anticlinal forms, the axes of which are, as a rule, inverted. In any single transverse section, the succession of the beds on the opposite sides of the median line of the band is identical, and the highest zone of the black shales everywhere passes up conformably into the basal bed of the surrounding greywackes. The varying width of the band is dependent simply upon the varying elevation of the crown of the anticlinal. Where the band is of least diameter, only the highest beds of the Birkhill shales rise from below the greywackes. As the band expands, the underlying zones emerge one by one in its centre, till finally, in the widest exposures, we recognize the deepest strata of the Glenkiln shales.

It was shown by plans, sections, and descriptions of every exposure of consequence within the Moffat district that precisely similar results are arrived at with respect to the remaining black shale-bands. To the south of Moffatdale, the Moffat beds agree essentially with those of Dobb's Linn; but to the north the whole formation diminishes in collective thickness, and the highest division gradually loses its fossiliferous black shales.

These facts place it beyond question that all the carbonaceous and Graptolitiferous shales of the Moffat area are portions of one and the same originally continuous deposit—the *Moffat Series*, which is now the oldest visible rock-group in the district, being everywhere inferior to the prevailing greywackes, through which it invariably rises from below in greatly elongated anticlinal forms.

In the rigid restriction of distinct groups of fossils to a few feet of the succession, the rocks of the Moffat series resemble the thin-bedded Silurians of Scandinavia and North-eastern America. From analogy it may be suspected that they similarly represent an enormous period of time. The correctness of this inference is demonstrated by the evidence afforded by the known geological range of their organic remains. The Graptolithina of the Lower or Glenkiln division are those of the highest Llandeilo Flags of Wales, the corresponding Middle *Dicranograptus*-schists of Sweden, and the Norman's Kiln shales that *underlie* the Trenton (Bala) Limestone of New York. The Hartfell species occur in the Bala beds of Conway, etc., the higher *Dicranograptus*-schists of Sweden, and the Utica and Lorraine shales that *overlie* the Trenton Limestone. Those of the Birkhill shales agree almost species for species with the fossils of the Coniston Mudstone of Cumberland, the Kiesel Schiefer of Thuringia, and the Lobiferous beds of Sweden, which lie at the summit of the Lower Silurians of their respective countries. Hence it may be considered certain that the Glenkiln shales are of highest Llandeilo age, that the Hartfell shales stand in the place of the Bala or Caradoc of Siluria, and that the Birkhill shales correspond to the Lower Llandovery.

The insignificant thickness of these three formations in the Moffat district is in strict agreement with the well-known north-westerly attenuation of the Lower Silurian rocks in Wales, England, and in Western Europe generally.

It was pointed out that these results, when carried to their legitimate conclusion, harmonize all the apparently conflicting facts hitherto collected among the Lower Silurians of the south of Scotland. We have a complete explanation of such difficulties as the remarkable lithological uniformity of the predominating strata, the absence of associated igneous rocks, the peculiar localization of the fossils, their identity along certain lines, and their rapid and peculiar impoverishment along others. We reduce, at a single stroke, the apparently gigantic thickness of the South Scottish Silurians to reasonable limits, and at the same time bring them into perfect harmony with those of Western Europe and America.

II.—December 5, 1877.—Prof. P. Martin Duncan, M.B., F.R.S., President, in the Chair. The following communications were read:—

1. "On the Building-up of the White Sinter Terraces of Roto-Màhànà, New Zealand." By the Rev. Richard Abbay, M.A., F.G.S.

The author described the structure and mode of formation of the so-called "White Terrace" of the Roto-Màhànà, which is produced by a deposit of silica from the water of a geyser situated on the side of a small hill of rotten rhyolitic rock, about 100 feet above the surface of the warm lake (Roto-Màhànà), into which the water from the geyser finally flows, and the foot of the siliceous terrace projects. The geyser basin, which is between 300 and 400 feet in circumference, has steep walls broken through only on the side towards the lake, where the water flows down to form a succession of terraces, which are really shallow basins, over the outwardly inclined edges of which the water flows, depositing the dissolved silica in a white subflocculent form on the edges and bottoms of the basins in proportion as the water cools. The author showed how this arrangement produced the peculiarly formed siliceous deposit of the terraces, and that as the growth of the latter is evidently upwards as well as outwards, it seems probable that the geyser pipe has slowly worked its way up the hill by the solvent action of the heated water from the level of the lake to its present elevation.

2. "Additional Notes on the Dimetian and Pebidian Rocks of Pembrokeshire." By Henry Hicks, Esq., F.G.S.

The additional facts communicated by the author show that at a distance of about 10 miles to the east of the Dimetian axis of St. David's there is another ridge of these rocks, which also runs nearly parallel with it. This is also flanked by Pebidian and Cambrian rocks, and made up of rocks like those in the St. David's axis.

The *Dimetian* formation, so far as it is at present known, consists chiefly of the following rocks:—

1. Quartz porphyries, containing frequently perfect quartz crystals (double pyramids), subangular masses of quartz, and crystals of felspar in a felspathic matrix.

2. Fine-grained greyish quartz-rocks, very compact, and interstratified with the above.

3. Ashy-looking shales of a dull green colour, sometimes highly indurated, but usually showing lines of lamination. Microscopically these show basaltic characters, and are probably greatly altered interbedded basaltic lavas.

4. Compact granitic-looking rocks.

5. Quartziferous breccias.

6. A series of compact quartzites and crystalline schists, interstratified by green and purple altered basaltic lavas, with a slaty and schistose foliation, and by some dolomitic bands.

Of the *Pebidian* formation new areas were added, and the portions described in the author's previous paper were further extended, and details as to the chief mineralogical characters added. At the base of the series resting unconformably on the Dimetian is seen an agglomerate composed of large angular masses of a spherulitic felstone, pieces of quartz and quartzites, indurated shales, crystalline schists, etc., cemented together by a sea-green matrix of felstone. These are followed by conglomerates of the same materials, which are again succeeded by indurated shales, often highly porcellanitic in character, with a conchoidal fracture.

These are followed by a thick series of silvery white and purplish shales and green slates, alternating with fine and rough ashes, often conglomeratic, hornstone breccias, felstone lavas, etc.

The series, as exhibited at St. David's, has a thickness of over 8000 feet; and as it is everywhere, so far as yet seen, overlapped unconformably by the Cambrians, it may probably be of much greater thickness. It evidently consists very largely of volcanic materials, at first derived from subaerial, but afterwards from submarine volcanos. These materials, however, were also undoubtedly considerably aided by sediments of a detrital origin.

The whole series shows that the sediments have undergone considerable changes, but yet not sufficient to obliterate the original characters, and the lines of lamination and bedding are usually very distinct. That they were altered nearly into their present state before the Cambrian sediments were deposited upon them is clear from the fact that the pebbles of the Cambrian conglomerates which rest immediately on any portion of the series are almost invariably made up of masses of the rocks below, cemented by gritty materials on an unaltered matrix, and from which the pebbles may be easily removed. The great conglomerates at the base of the Cambrians, everywhere in Wales, indicate that there were beach- and shallow-water conditions over those areas at the time, and that the sea was then encroaching on an uneven land, becoming gradually depressed to receive the subsequent Cambrian sediment.

3. "On some Precambrian (Dimetian and Pebidian) Rocks in Caernarvonshire." By Henry Hicks, Esq., F.G.S.

In this paper the author gave an account of the special examination of the great ribs of so-called intrusive felspathic and quartz porphyries which are found associated with the Cambrian rocks in Caernarvonshire, made by him in company with Prof. Hughes, Mr. Hudleston, and Mr. Homfray last summer. He described sections at and near Moel Tryfaen and across the mass from Pen-y-groes to Talysarn, in which he showed that instead of being of an intrusive nature, as hitherto supposed, the whole, with the exception of a few dykes at those parts, is made up of bedded volcanic rocks, lavas, breccias, etc., similar to those found in the Pebidian series at St. David's, and that the Cambrian rocks, instead of being intruded by this mass, rests everywhere upon it unconformably, and the pebbles in the conglomerate of the Cambrian at the base are, as at St. David's, identical with, and must have been derived from the rocks below. Similar results were obtained in the examination to the north and south of Llyn Padarn, and the conclusion, therefore, at which the author has arrived with regard to the great mass which extends from Llanellyfine in the south of St. Ann's chapel in the north is that it is entirely Precambrian, and that it belongs to the series described by him under the name Pebidian at St. David's.

The other mass, extending from Caernarvon to Bangor, he considered also entirely Precambrian; and from the mineral characters exhibited by a portion of this mass directly behind Caernarvon, he thought it would prove to be, at least at this part, of Dimetian age. The altered beds near Bangor and their associated quartz felsites he considered entirely of Pebidian age, as there is no evidence that the Dimetian rocks are exposed there.

4. "On the Precambrian Rocks of Bangor." By Prof. T. McKenny Hughes, M.A., F.G.S.

The author described a series of slates, agglomerates, and porphyritic rocks which, near Bangor, are seen to pass under the Cambrian and seem to rest conformably upon the quartz felsites and granitoid rocks of Caernarvon. He thought that the Bangor beds were the equivalents of the felsitic and porphyritic series of Llyn Padarn, and, in order to bring his interpretation into harmony with the observations of Prof. Ramsay, he explained away the apparent melting of the ends of the Cambrian beds in that section by twists, faults, and dykes. He referred the apparent unconformity recorded by Mr. Maw entirely to rock structure, produced by cleavage on beds of different texture.

He considered that in the main the Bangor beds were the equivalents of the Pebidian of Dr. Hicks, while the Caernarvon beds nearly represented his Dimetian. But he thought there was as yet no proof of an unconformity between these formations. He would explain the apparent unconformity at St. David's by a continuation of bends and faults and joints mistaken for bedding, and would refer the brecciated rock of Low Moor, near St. David's to the Pebidian, thus taking it on the wrong side of the supposed unconformity. He thought that the green beds in the Dimetian were, in all the cases where he had been able to examine them, originally dykes.

He saw, therefore, no reason, from an examination of other areas, to suspect any different explanation from that suggested by the examination of the Bangor and Caernarvon district, viz. that we have in the Bangor and Caernarvon beds one great volcanic series, on which the Cambrian conglomerates and grits rest with a probable unconformability.

An appendix by Prof. Bonney, on the microscopical examination of the rocks referred to, accompanied this paper.

## CORRESPONDENCE.

### "CONCRETIONARY BANDS" OR "CONGLOMERATES" OF LAMBAY ISLAND.

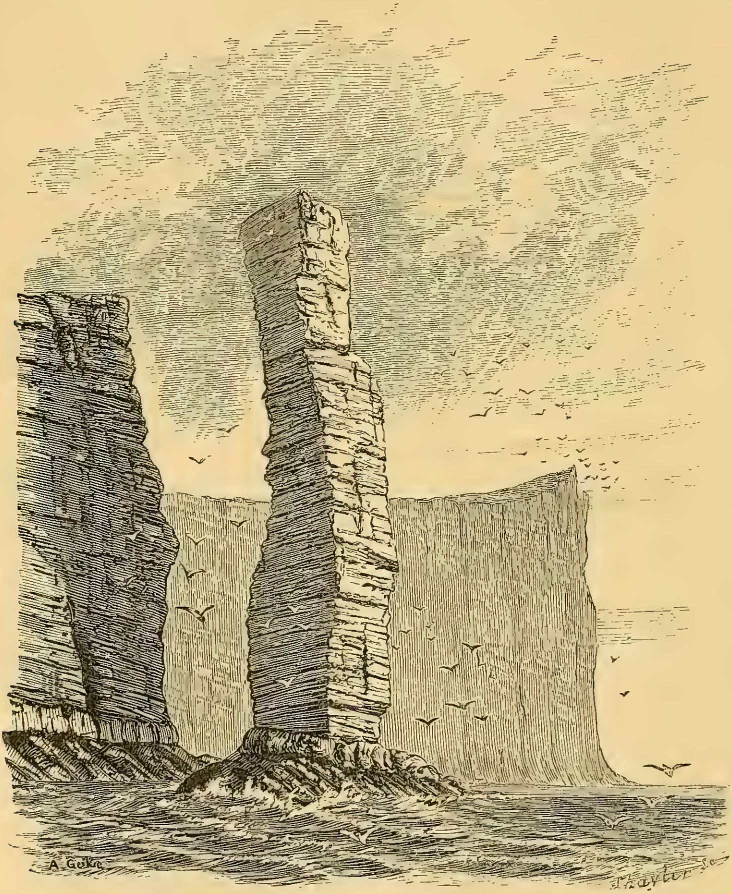
Sir, — In the paper "On the Borrowdale Series and Coniston Flags," in the Quarterly Journal of the Geological Society for Aug. 1877, p. 479, the authors speak of "Concretionary bands" "called by" the late "Mr. Du Noyer, coarse conglomerates," and according to the late Prof. Jukes, containing "pebbles" with Silurian corals attached. In next page these "conglomerates" or "concretionary bands" are said to form a portion of an ash-breccia series, but no reason is given for what would seem to be an entirely unnecessary correction of the descriptions quoted from Mr. Du Noyer and Prof. Jukes; nor is it stated why the rocks are referred to as "concretionary bands."

These descriptions, quoted at p. 479, will of themselves show the difficulty of accepting the concretionary nature of the Lambay rock referred to; the matrix being of "black mud," inclosing pebbles of "cleaved slate," "grey grit," "grey limestone," "greenish-grey greenstone," "ash," and "limestone conglomerate inclosing rolled pebbles of greenstone": some of these fragments supporting attached Silurian corals.

The unqualified application of the word "concretionary," as an amendment to Mr. Du Noyer's "coarse conglomerate," to such rocks, seems a singular use of the term, though it can scarcely be meant to convey the idea that the writers quoted did not know the difference between concretionary rocks and conglomerates.

A. B. Wynne.

Murree, *Oct.* 1877.




"THE OLD MAN OF HOY."

Sketched from the Sea.

THE

# GEOLOGICAL MAGAZINE.

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No. II.—FEBRUARY, 1878.

## ORIGINAL ARTICLES.

### I.—The Old Man of Hoy.

By Prof. Archibald Geikie, LL.D., F.R.S.,
Director of the Geological Survey of Scotland.

(PLATE II.)

THE tidal wave of travellers which, thanks to railroads and steamboats, pours northward over the country every summer, even as far as John o' Groat's, has hardly as yet risen much beyond that utmost shore. The tourist stops short at the Pentland Firth; indeed, when he reaches its bare treeless coast, and finds that there is really no traditional house at John o' Groat's (though a good inn, with careful host and kindly hostess, should tempt him to rest there a while), he is in a hurry to get back by daylight to the busy hum of men in the hyperborean city of Wick or Thurso, and as eager to flit southwards again next morning. He makes a fatal mistake, however; for he misses the very points which it would have been worth his while to make the whole of his long journey to see. Let him, for instance, take up his quarters for a day or two by the side of the Pentland Firth, and sitting or lying on one of its grim cliffs, let him spend his hours watching the race of its tideway. Nowhere else round the British Islands can he look down on such a sea. It seems to rush and roar past him like a vast river, but with a flow some three times swifter than our most rapid rivers. Such a broad breast of rolling eddying foaming water! Even when there is no wind, the tide ebbs and flows in this way, pouring now eastwards now westwards, as the tidal wave rises and falls. But if he should be lucky enough to come in for a gale of wind (and they are not unknown there in summer, as he will probably learn), let him by no means fail to take up his station on Duncansbay Head, or at the Point of Mey. The shelter of a flagstone "dyke" and a waterproof will save him from any ulterior consequences of the exposure, or should he be under some misgivings on this point, when he gets back to the shelter of the inn at John o' Groat's, mine host has sundry specifics of well-tried potency, at the very sight and taste of which rheums, catarrhs and the rest of that tribe of ailments at once decamp. Ensconced in his "neuk," he can quietly try to fix in his mind a picture of what he sees. He will choose if he can a time when the tide is coming up against the wind. The water no longer looks like the eddying current of a mighty river. It rather resembles the surging of rocky rapids. Its surface is one vast sheet of foam and green yeasty waves. Every now and then a huge billow rears itself impatiently above the rest, tossing its sheets of spray in the face of the wind, which scatters them back into the boiling flood. Here and there, owing to the configuration of the bottom, this turmoil waxes so furious that a constant dance of towering breakers is kept up. Such are the terrible "Roost of Duncansbay," and the broken water grimly termed the "Merry men of Mey." With a great gale from the north-east or south-east, the shelter even of the stone wall on Duncansbay Head would be of little avail. For solid sheets of water rush up the face of the cliffs for more than 100 feet, and pour over the top in such volume, that it is said they have actually been intercepted on the landward side by a dam across a little valley, and have been used to turn a mill. Should the meditative tourist be overtaken by such a gale, he will find shelter in the quaint cottage of the kind-hearted but hard-headed John Gibson, who, perched like a sea-eagle at the head of a tremendous chasm in the cliffs, can spin many a yarn about the tempests of the north.

No one can see such scenes without realizing, as he probably has never done before, the restless energy of nature. His eyes are opened. He feels how wind and rain, wave and tide, are leagued together, as it were in spite of their apparent antagonism, to batter down the shores. Everywhere he witnesses proofs of their prowess. Tall gaunt stacks rise out of the waves in front of the cliffs of which they once formed a part. Yawning rents run through them from summit to base; their sides are frayed into cusp and pinnacle that seem ready to topple over when the next storm assails them; their surf-beaten basements are pierced with caverns and tunnels into which the surge is for ever booming. On the solid cliffs behind, the same tale of warfare is inscribed. But the traveller who has seen so much will perforce desire to see more. From his perch on the southern side of the foaming Pentland Firth he looks across to the distant hills of Hoy—the only hills indeed which are visible from the monotonous moorlands of northern Caithness, save when from some higher eminence one catches the blue outline of Morven on the southern sky-line. The Orkney Islands are otherwise as tame and as flat as Caithness. But in Hoy they certainly make amends for their general featureless surface. Yet even there it is not the interior, hilly though it be, but the western coast-cliffs which redeem the whole of the far north of Scotland from the charge of failure in picturesque and impressive scenery. One looks across the Pentland Firth and marks how the flat islands of the Orkney group rise from its northern side as a long low line until westwards they mount into the rounded heights of Hoy, and how these again plunge in a range of precipices into the Atlantic. Yellow and red in hue, these marvellous cliffs gleam across the water as if the sunlight always bathed them. They brighten a grey day, and grey days are only too common in the northern summer; on a sunny forenoon, or still better on a clear evening, when the sun is sinking beneath the western waters, they glow and burn, yet behind such a dreamy sea-born haze, that the onlooker can hardly believe himself to be in the far north, but recalls perhaps memories of Capri and Sorrento, and the blue Mediterranean. Looking at them from the mainland, we are soon struck by one feature at their western end. A strange square tower-like projection rises behind the last and lower spur of cliff which descends into the sea. We may walk mile after mile along the Caithness shore, and still that mysterious mass keeps its place. As we move westwards, however, the higher cliffs behind open out, and we can see on a clear day with the naked eye that the mass is a huge column of rock rising in advance of the cliff. It is the Old Man of Hoy—a notable landmark, well deserving its fame.

Let no tourist who has got up as far as Thurso hesitate to cross the Firth and reach Stromness in Orkney. He will find a steamer ready to carry him thither in a few hours, and in the voyage will pass close under the grandest cliff in the British Islands. Above all he will make the personal acquaintance of the Old Man, or at least will be brought so near as to conceive a very profound respect for him. The accompanying vignette was sketched from the vessel in this passage, and though by no means taken from the most picturesque point of view, may serve to convey some notion of the form and size of this the most remarkable feature in Orkney scenery. The Old Man is a column of yellow and red sandstone more than 600 feet high. It stands well in front of the cliff, with which however it is still connected by a low ridge of ruined blocks. Doubtless one main cause of its impressiveness lies in the fact that its summit is considerably higher than the cliff behind it. Thus it stands out against the sky even when seen from a distance. Its base is washed on three sides by the waves, which rise and fall over a low reef running out from underneath the base of the column. Formerly a huge buttress, like the Giant's Leg of Bressay in Shetland, used to project into the sea. But it has been swept away and for many years the Old Man has had to keep his watch and wage his battle with the elements with the support of but one leg.

Unless the ground-swell be too heavy, the steamboat usually keeps close enough to the base of the great precipices to allow the masonry of this wonderful obelisk to be distinctly seen. Like the cliff behind, it is built up of successive bars of sandstone forming portions of horizontal or very gently inclined strata. Its base, however, rests on a pedestal of different materials, consisting of two well-defined bands, both of which can be traced stretching landwards and passing under the base of the cliff. The lower of these two bands is plainly marked by lines of parallel stratification inclined at a considerably higher angle than the dip of the sandstones, and evidently composed of something quite different from them. Viewed thus from the sea in a brief and passing way, the column can be recognized as composed of at least two very distinct portions. The main pillar rests unconformably upon a platform of older and tilted strata.

It is only when one lands on the island of Hoy, and examines the cliffs in detail, that the true nature and history of the threefold bars of the Old Man can be made out. The yellow and red sandstones are then found to present the ordinary characters of the Upper Old Red Sandstone, to which they are with probability referred, though as yet they have yielded no fossils. Irregularly alternating in thick and thinner beds, they are rent by innumerable perpendicular joints. By means of these divisional lines, slice after slice falls away from the face of the cliffs, which thus maintain their precipitous front towards the Atlantic. Except in regard to their scenic features, these sandstones, however, are less full of interest than the two bars of the Old Man's pedestal. The upper bar consists of a band of dark amygdaloidal lava with a slaggy surface. The same rock appears elsewhere, rising out from beneath the sandstones of the precipices, particularly at the north-western headland, where it consists of three or more distinct bands with well-stratified volcanic tuffs. To the north-east of that headland, on a tract of lower ground intervening between the base of the hills and the edge of the sea, several well-marked volcanic "necks" or pipes occur, representing some of the vents from which the streams of lava and showers of ash were poured. The complete interstratification of the beds of erupted material with the lower portion of the sandstones proves that the volcanic action showed itself at the beginning of the deposition of the Upper Old Red Sandstone in this region. Another little vent may be observed on the Caithness coast, near John o' Groat's House; perhaps some may still remain to be noticed among the central and northern members of the Orkney Islands. It seems to have been a singular and local outburst of volcanic energy during Upper Old Red Sandstone times—the only one yet discovered to the north of the Highlands. The uppermost bar then of the pedestal on which the Old Man has taken his stand is a massive sheet of lava.

The lower bar belongs to a very different period, and has a totally dissimilar history. On looking more closely into the strata which, even seen from the sea, plainly lie unconformably below the lava and its overlying sandstones, we find that they consist of dark thin-bedded sandstones, shales and impure limestones. In short, they are a portion of the great series of deposits known as the Caithness flagstones. On many of their exposed surfaces shining jet-black scales, bones and teeth of the characteristic fishes of these flagstones may be noticed. What a suggestive picture of the imperfection of the geological record is presented to us by some of these weather-beaten or surf-worn sheets of rock! We pick up from their crannies the broken whelks, nullipores, and corallines, tossed up by the last storm from the zones of life now tenanting the sea below us. The limpet and sea-anemone, the whelk and barnacle, are clinging to the hardened sand over which the *Osteolepis* and *Coccosteus* and their bone-cased brethren disported in the ancient northern lake of Lower Old Red Sandstone times. Nay, we may now and then watch a living mollusc creeping over the cuirass of a palæozoic fish. Yet who can realize the lapse of time which here separates the living from the dead?

Below and beyond the horizon of the flagstones no evidence among the Hoy Cliffs remains to lead us. But in the neighbouring isles of Pomona and Gremsa, bosses of crystalline rocks—granite, gneiss and schists—project from under the flagstones. They are wrapped round with conglomerates, doubtless representing the shore-gravel heaped up around them when they rose as islets out of the Old Red Sandstone lake.

So much for the materials out of which the Old Man has been carved. And now a few words as to the process of carving. If the traveller who has reached Stromness finds himself with even one spare day at his disposal, he cannot employ it to more conspicuous advantage than by taking a boat with a couple of stalwart Norse-like Orcadian boatmen, crossing the strait to Hoy, and ascending that island by the Cam and the north-western headland, until he finds himself at the summit of the great western precipice with the surface of the surging Atlantic some 1300 feet below him. The scene tells its own tale of ceaseless waste, and needs no lecture or text-book for its comprehension. Pinnacles and turrets of the richly-tinted sandstone roughen the upper edge of the cliff, often fretted into the strangest shapes, and worn into such perilous narrowness of base that they seem doomed to go headlong down into the gulf below when the next tempest sweeps across from the west. Butresses, sorely rifted and honey-combed, lean against the main cliff as if to prop it up; but separated from it by the yawning fissures which will surely widen until they wedge off the projecting masses, and strip huge slices from the face of the cliff. One sees as it were every step in the progress of degradation. It is by this prolonged splitting and slicing and fretting that the precipice has been made to recede, and has acquired its shattered but picturesque contours. The Old Man is thus a monument of the retreat and destruction of the cliffs of which it once formed a part. To what accidental circumstance it may have owed its isolation, we may not be able to say with certainty. But it is suffering in the prevalent decay. Every year must insensibly tell upon its features.

On the calmest day some motion of air always keeps playing about the giddy crest of these precipices, and a surge with creaming lines of white foam meets at their base. But when a westerly gale sets in, the scene is said to be wholly indescribable. The cliffs are then enveloped in driving spray torn from the solid sheets of water which rush up the walls of rock for a hundred feet or more, and roll back in thousands of tumultuous waterfalls. The force of the wind is such as actually to loosen the weathered parts of the rock and dislodge them. Thus along the mossy surface of the slope which ascends inland from the edge of the cliff, large flat pieces of naked stone may be picked up by scores lying on the heather and coarse grass, whither they have been whirled up from the shattered crags by successive gusts of the storms.

The destruction of this coast-line has not yet, however, wholly effaced traces of other powers of waste which have long since passed away. On the very edge of the cliff, to the south-east of the Old

Man, some well-preserved striations on the sandstone point to the movement of the ice-sheet of the glacial period across even the hilly island of Hoy in a N.W. and S.E. direction. Again in the green corry at the Cam of Hoy, some beautifully perfect little moraines remain to show that after the great land-ice had subsided, the snow-fall in these northern regions continued heavy enough to nourish in so small an island as Hoy groups of valley glaciers. Though the general form of the hills and valleys remains now much as it was when the last lingering glacier melted away, there have been stupendous changes since then in the shaping of the precipices. At that time the Old Man still formed a portion of the solid cliff. It is in the ensuing interval that this impressive landmark has been left during the destruction of the surrounding masses. Long may he be able to stand his ground! When his last hour comes, as come it must, may some reverential geologist, duly impressed with a sense of the potency of denudation in the relief of the land, be there to pay the last honours to his dust!

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## II.—Geological Sketch of a Visit to Ireland in August, 1876.[1]

By Dr. Ferdinand Roemer,

Professor of Mineralogy in the University of Breslau.

I HAVE been this autumn in the Land of the Giant's Causeway and of the Giant Stag. For a long time it had been my earnest desire to become acquainted with "The Green Isle." In my colleague, Professor von Lasaulx, I found a wished-for companion on my journey. It is easy to get to Ireland. In a single night's journey one is whirled from London to Dublin *viâ* Holyhead. In Dublin the best directions for a geologist are to be had at the Geological Survey Office for Ireland, which forms a department of the Government Geological Survey of Great Britain. Prof. Hull, the Director of the establishment, and Mr. Hellier Baily, the Palæontologist attached to it, afforded me, with the greatest kindness, every necessary assistance. Besides these two gentlemen, who reside in Dublin, the Geological Survey includes a number of other geologists scattered through the country, who carry out its purposes. A large portion of Ireland is already surveyed, and the maps containing the results for the most part published. Explanations of these maps appear under the title of "Memoirs of the Geological Survey." The last part that was published this year bears the title: "Explanatory Memoir to accompany Sheets 21, 28, and 29 of the Maps of the Geological Survey of Ireland, including the Country around Antrim, Larne, and Carrickfergus, by Edward Hull, Director, with Palæontological Notes by W. H. Baily, Dublin, 1876." This part treats of one of the most remarkable districts of the North of Ireland. Several years ago a good general geological map of Ireland was published by the late Professor Jukes, then the distinguished Director of the Survey, the title being: "Geological Map of Ireland, by Joseph Beete Jukes (E. Stanford, London), 1864."

[1] From the Neues Jahrbuch für Mineralogie, Geologie und Paläontologie, Jahrgang 1877. Translated from the German by Richard J. O. Mulrenin.

Since the first appearance in 1865 of the Journal of the Royal Geological Society of Ireland (new series), it has been issued regularly, and contains many important geological articles on the country. The Transactions of the Royal Irish Academy contain some interesting papers on geology and palæontology, as, for instance, Professor T. H. Huxley's and Dr. Percival Wright's description of remarkable reptiles in the Coal-measures of the Co. Kilkenny ("On a Collection of Fossil Vertebrata from the Jarrow Colliery, County Kilkenny, Ireland," vol. xxiv. 1867).

Several public collections in Dublin are important in a geological sense. We may mention in the first place the Museum of the Royal College of Science. Here are to be found in a large gallery on the upper floor the collections of the Geological Survey. They comprise beautiful series of Irish rock-specimens, and of the fossils of the several sedimentary formations. Among the latter especially are splendid examples of the *Palæopteris Hibernica*, Schimp. (*Adiantites Hibernicus*, R. Griff. and Ad. Brongn.), from the upper division of the Old Red Sandstone, or Devonian beds, particularly that which contains the Yellow Sandstone of Kiltorkan Hill, in the Co. Kilkenny, as well as from the other formations containing remains of vegetable and animal life. Moreover, there are rich collections of fossils from the Carboniferous Limestone, which, of all the sedimentary formations in Ireland, occupies the largest space. From the upper or productive Coal-measures are some of the originals of the remarkable reptiles already referred to as described by Professor Huxley and Dr. Percival Wright. A complete skeleton of the *Cervus megaceros* is a conspicuous ornament to the hall. The Museum of the Royal Dublin Society, which is under the excellent management of Dr. A. Carte, contains also much that is really remarkable. The principal ornament of this collection consists in the complete and original specimen of the *Plesiosaurus Cramptoni*, the largest of the species yet discovered, which was found in the Lias of Whitby. The specimen of *Didus ineptus*, complete all but the skull, which has been artificially supplied, is likewise exceedingly interesting. Numerous remains of this extinct bird were found a few years ago in draining a swamp in the island of Mauritius; an event which makes the conjecture probable that, in the course of time, several more specimens of this singular bird may be brought to Europe. There are besides in this Museum complete skeletons of the *Cervus megaceros*, male and female. On beholding these, one cannot avoid wishing that a few living examples of this majestic animal, which must have thrown into the shade all other species of the beautiful deer tribe, had continued to exist in our present world. Several heads with the antlers, and numerous bones, of the same magnificent animal, are likewise exhibited. Some of the latter present the singular appearance of being marked with deep cuts or indentations, which, on account of their sharpness and smoothness, one would naturally suppose to be the effect of a sharp tool worked by human agency, if the well-observed circumstances under which these marked bones and organic remains were discovered did not refute this supposition. These appearances were, for the first time, described by Professor Jukes in 1863 ("On some indentations in bones of a *Cervus megaceros*, etc.," Journ. Geol. Soc. Dublin, vol. x., pt. 2, p. 127 *et seq.*), and afterwards by Dr. Carte ("On some indented bones of the *Cervus megaceros*, found near Lough Gur, County of Limerick," Journ. Geol. Soc. Dublin, vol. i., pt. 2, 1865–1866, 2nd series, p. 151 *et seq.*), who further explained and illustrated them. Both observers have demonstrated that wherever such portions of skeletons have been observed to be marked *in situ*, a bone fitting into the indentation has been found with it in such a position that its motion to and fro would at once explain the cause of the indentation. The only doubt remaining was as to the origin of the motion of friction backwards and forwards. Dr. Carte believes that the effect must have been caused by the rising and sinking of the bog in the long course of ages, the peat having been alternately contracted by the dryness of summer and expanded by the damp and wet of winter. This remarkable phenomenon deserves particular attention, as it shows how effects are produced through the agency of inanimate nature, which, on superficial observation, may be easily accepted as having been caused by the agency of man. Finally, the same Museum also contains the greater part of the extensive collection made by Sir Richard Griffith, of the Carboniferous Limestone and Silurian fossils of Ireland. These collections have been described by Professor McCoy. The original specimens of the remarkable genus *Palæchinus* particularly arrested my attention. Sir Richard John Griffith, the constructor of the first Geological Map of Ireland, and who has done so much for the geology of that country, is still living in Dublin at the great age of 92 years. I did not fail to call upon him to express to him my deep respect. He related to me what difficulties he had to overcome when he first began to construct his maps, at a time when there were scarcely decent roads through the country, much less railways, and he had himself to obtain the topographical information which was to serve as a foundation for his geological undertakings.

A third collection worthy of a visit is that of Trinity College. It is arranged in a large hall belonging to the range of magnificent buildings composing this institution. Here also several skeletons of the *Cervus megaceros* at once arrest the attention, and particularly a male, of extraordinary size. There are also several other skeletons, including that of a female. The latter is readily distinguishable, as is the case with several other species of deer, by being hornless, the reindeer forming an exception; this fact was at one time doubted. The hornless skulls of the females naturally attracted less notice[1] on the part of the uneducated finders than those of the males, and on that account remained a long time unknown. Besides the above, there are some valuable specimens of fossils, minerals, and precious stones.

Some excursions in the immediate and more distant environs of

[1] They were generally supposed by the Irish labourers to be the skulls of horses, and so were thrown aside.

Dublin afforded a variety of information. One of them related to the presence of *Posidonomya Becheri* at Loughshinny near Rush, to the north of Dublin. Black shales sometimes passing into hard limestone, traversed by veins of quartz, are numerous on this part of the coast. Some of these strata have their surfaces covered with the shells of *Posidonomya Becheri.* The appearance of the whole strikingly resembling that of Barnstaple in Devonshire (the Lower Culm Beds of Murchison). Here, in Ireland, however, the layers of rock containing *Posidonomya* are in closer connexion with the principal mass of the Carboniferous Limestone which is to be seen in the immediate neighbourhood, where extensive quarries are worked, while in Devonshire the Carboniferous Limestone is wholly wanting, and the *Posidonomyæ* are found there in the Culm formation which takes its place. At numerous other points, likewise, the Irish geologists have met with the same mollusc with similar distinguishing marks. It is furthermore found in the Coal-measures of Northumberland in precisely the same circumstances. It is a matter of great interest to determine the exact horizon which the *Posidonomya Becheri* occupies in the Coal-measures of Ireland and England, because it will then be possible to determine to what division of the Carboniferous Limestone our German sandstone Culm formation corresponds, this being palæontologically characterized by the same mollusc. I have during my journey collected a number of facts bearing upon this point, which I shall publish on a future occasion.

The Irish metropolis and its environs having been visited, there succeeded longer excursions into more distant districts of the island. The first one was to the charming Lakes of Killarney, so celebrated for their picturesque beauty. They are situated in the County of Kerry, which occupies the south-western corner of Ireland. In order to get to this district, one is obliged to traverse the whole of the southern half of Ireland from north-east to south-west. The journey is for the most part rather monotonous, but not disagreeable; it proceeds over the great central plain, the foundation of which is formed by horizontal or slightly inclined strata of Carboniferous or Mountain Limestone. But it is only occasionally that the Carboniferous Limestone crops up at the surface. In most places it is covered by a layer of gravel of greater or less depth. At times this diluvial gravel, composed of water-worn pieces of limestone, and partly also of other kinds of rocks, is raised into ridges or eskers of moderate elevation. Thus the surface of the country is, to a certain extent, undulating. The hollow flats which lie deeper are, far and wide, covered with peat-bogs. On the whole the country appeared to me by no means such a wilderness, nor so badly cultivated, as I had imagined from the perusal of many descriptions of it. The brilliant green of a rich sward, caused by the great humidity of the climate, does not give the impression of a desert or barren country.

Higher mountain summits first begin to appear in the southern portion of the island. They are steep and rugged mountains from

2000 to 3000 feet in height, not wooded, which stretch through the counties of Cork and Kerry from east to west as a strongly linked chain. They consist of very steep banks of grey and reddish sandstones, and quartz rocks of the Old Red formation. The characteristic fossil fish found in this formation in England and Scotland scarcely show a trace of their existence in the corresponding Irish rocks. Igneous rocks of the porphyry class have broken through the Old Red Sandstone at certain points. It is on the borders of the Carboniferous Limestone, and between it and the Old Red Sandstone, that the Lakes of Killarney are situated. The strata of the former are here raised at a great angle, and towards the south occur among those of the Old Red Sandstone as apparently later deposits. The attractive feature of these lakes, which every year brings thousands of visitors and sight-seers, depends principally on the beautiful forms and mighty precipices of the Old Red Sandstone peaks, which on the south surround these lovely sheets of water. At the same time the lakes themselves, with their numerous islands and rich clothing of verdure, are beautifully picturesque. This vegetation, of a wonderfully luxuriant growth, favoured by an exceedingly mild and humid climate, consists in part of evergreen plants, among which is conspicuous the strawberry tree (*Arbutus unedo*, L.), otherwise confined to the countries bordering on the Mediterranean. We ascended Mangerton, which rises to a height of 2756 feet, from the summit of which an extensive view over the lakes and their surrounding country rewards the visitor. These mountains, however, clothed to their tops with a thick garment of verdure, do not offer good subjects for geological investigation. Mangerton is not by any means the highest point of the Old Red Sandstone mountains, as Carrantuohil (3474 ft.), lying further to the west, overtops it considerably.

Another excursion was undertaken from Dublin to the north-west districts. The Earl of Enniskillen, whose researches on the subject of fossil fishes have made his name known far and wide, had the kindness, on ascertaining my presence in Ireland, to invite me to his residence at Florence Court, near Enniskillen, in order to inspect his celebrated collection. The town of Enniskillen is situated at the southern extremity of Lough Erne, in the Co. Fermanagh, and Florence Court is a few miles to the south. For three days I enjoyed the proprietor's hearty and thorough hospitality at this magnificent demesne, while most agreeably occupied under his guidance with the examination of his collection. From every country, and out of every formation, are gathered, in this magnificent collection (the result of forty years' labour), the finest specimens of fossil fish. It has but one rival in England, viz. Sir Philip Egerton's collection at Oulton Park, in Cheshire. Both the Earl and Sir Philip, connected for many years by bonds of friendship and common studies, having had their ichthyological tastes developed by Agassiz, have cultivated them and made collections together. In many respects the one collection forms the counterpart of the other. Florence Court is also well known to palæontologists as the original locality for certain fossil

Crinoidea. The beautiful cups of the *Actinocrinus amphora* and of several species of the genera *Platycrinus*, *Pentremites*, etc., which are scattered though many collections, derive their origin from this place and neighbourhood. The quarries in the Carboniferous Limestone, from which these fossils were formerly obtained, are not, however, worked any longer at present, and the place is accordingly closed up. With great difficulty only, could I obtain some small examples of *Pentremites Derbiensis*, which appear on the weathered surface of large blocks of limestone that are heaped up in wild confusion under a steep limestone ridge.

From Enniskillen we directed our way northwards in order to view the remarkable and abrupt termination of the basaltic field of Co. Antrim, where it reaches the sea. This basaltic plateau, which spreads over more than 800 square miles of the North of Ireland, culminates in the Giant's Causeway, which, however, is not for the geologist its most remarkable termination. The railway leading to it runs through Londonderry, and then in a north-easterly direction as far as Portrush, a small town best known as a watering place. The Giant's Causeway is but a few miles distant from this. In the immediate vicinity of Portrush several remarkable geological phenomena are observable. A small rocky promontory is composed of an igneous doleritic rock common in this district. At this promonotory dark sedimentary strata, slightly inclined, show themselves on the surface of the sea-shore, forming reefs extending seawards. These are banks of dark grey rock composed of indurated clays, harder in some places than in others. It was with astonishment that we perceived certain strata of this rock filled with *Ammonites* and other characteristic fossils of the Lias; for, from the nature and position of the strata, one might have been inclined to ascribe a far greater antiquity to them. The organic contents of these strata indicate not only the presence of the Middle (?) and Lower Lias, but layers of the *Avicula contorta* are visible, characterizing the Rhætic formation. This shell, first described and figured from the North of Ireland by Portlock, has since been recognized as an important characteristic fossil at many places in Central Europe.

Eastwards from Portrush these Jurassic rocks disappear, and the White Chalk, overflown by the basalt, makes its appearance, forming grand scenery, which would not only rejoice the heart of the geologist, but must also attract the admiration of the ordinary spectator. Masses of snow-white chalk-rock a hundred feet high face the sea in perpendicular precipices, crowned by the sharply contrasted black basalt. *Belemnitella mucronata* and other distinguishing fossils make the geological position of the White Chalk certain. The boundary between chalk and basalt does not by any means run quite horizontal, but rises and falls in hills and hollows, evidently because the surface of the chalk at the time of its being overflowed by the basalt was very uneven. And so it becomes clear how further eastwards towards the Giant's Causeway the chalk disappears altogether, and the basalt descends to the level of the sea. The Giant's Causeway is itself a small low promontory of basalt washed by the waves, and during winter storms overflowed by the sea. It is simply the regularity of its columns that has made it celebrated. This regularity is particularly striking, as one sees not only the prisms from the side, but, by going over their tops, the broken ends, plainly showing the six-sided or polygonal sections. This peculiarity distinctly characterizes the phenomenon. The thickness of the columns, usually amounting to over a foot, corresponds to the breadth of the crevices between neighbouring columns, the spaces being mostly half an inch broad. The concavo-convex jointings of the columns are frequently developed in great perfection. On the land side the Giant's Causeway is bounded after the manner of an amphitheatre by perpendicular walls of basalt several hundred feet in height. Here, however, the regular prismatic formation is absent. The rock being partly amygdaloidal, and the cavities covered with various kinds of zeolites. Otherwise, the basalt of Northern Ireland is altogether of the self-same age with that of Germany and Central Europe, which is proved by the occurrence with it of a layer of red clay containing impressions of leaves of Miocene trees. Mr. W. H. Baily has particularly described such a stratum exhibiting this kind of plant-growth in the neighbourhood of the town of Antrim. It is only a few inches thick, and rests proximately on a ten to twelve foot deep series of strata holding lumps of iron-ore ("Notice of Plant-remains from Beds interstratified with the Basalt in the County of Antrim," Quart. Journ. Geol. Soc. 1869, vol. xxv. p. 162).

Having returned from the Causeway to Portrush, we pursued our journey from the latter to Belfast. On the way thither we had to cross in its entire length the great basaltic plateau of the North of Ireland. It is almost a level or rather undulating district, on whose surface the great dark blocks of basalt are everywhere scattered. But in the neighbourhood of the town of Antrim there rises a group of hills consisting of igneous rocks of an entirely different kind, and the central point of these is the round bowl-shaped Tardree mountain, a few miles from Antrim. Several quarries, in which the rock is worked for economic purposes, are situated on its borders. It is a light grey felspar rock, rich in quartz, and of the trachyte group. Professor E. Hull, who has lately fully described its characteristics ("Memoirs Geol. Survey: Explanatory Memoir to accompany Sheets 21, 28, and 29 of the Maps of the Geol. Survey of Ireland, including the country around Antrim, etc., Dublin, 1876," p. 17 *et seq.*), has named it Trachyte-porphyry, and J. Roth (Beitr. Petrogr. pluton. Gest., 1873, p. xxxiii) places it among the liparite group, following a published analysis by E. Hardman. According to Prof. Hull, the rock is covered by basalt, and is considerably older than the latter. We had not the opportunity of fully examining these conditions of the strata on our flying visit to the quarries. The isolated appearance of the rock in such a limited space is at any rate well worth observation. In no other part of Ireland are trachyte rocks known, [except to the west of Hillsborough, Co. Down.]

The environs of Belfast are also deeply interesting to the geologist.

This great manufacturing and business-like town, which is rapidly increasing, and threatens soon to exceed Dublin in the number of its inhabitants, lies at the edge of the great basalt plateau of the county Antrim, which here, as on the north coast at Portrush, falls towards the sea with a steep descent, and likewise covers the chalk and other sedimentary strata. These characteristics are strikingly prominent at Cave Hill, which is a steep and rugged mountain over a thousand feet high (1188 ft.), and about an hour's walk from the town. Here again the White Chalk crops out from under the basalt, the latter not being of a distinct prismatic form, but generally taking the composition of amygdaloid. Extensive quarries, in which the basalt is exposed, supply the finest views of its contact with the White Chalk, the divisional line being very distinct, from the great contrast of colour between the two rocks. It is not always horizontal, but runs in many parts very irregularly, and the basalt in many places sinks deep into the Chalk. Moreover, veins of basalt penetrate the Chalk in various places. Under the White Chalk another division of the Cretaceous formation is clearly observable, viz. a dark-green marly Greensand, containing *Exogyra conica*, *Pecten asper*, remains of *Callianassa*, and other fossils, by means of which it has been without hesitation classified by British geologists with the "Upper Greensand," and by D'Orbigny with the "Etage Cenomanien." At a short distance from the quarries other sedimentary rocks show themselves; the Lower Lias, the Rhætic, the Keuper, and the variegated sandstone, "Bunter Sandstein." The Lower Lias is without any doubt determined by *Gryphœa arcuata* and other characteristic species; the Rhætic is likewise distinguished palæontologically; the Keuper, a succession of red and green marly slates, interspersed with thin strata of sandstone containing mica and veins of gypsum, is easily distinguished; finally the variegated sandstone ("Bunter") appears in the plain along the sea-shore as a red sandstone, the boundaries of which on the side of the Keuper are often difficult to determine.

Between the Lower Lias and the "Cenomanien" Greensand all the other members of the Jurassic and Chalk formation are wanting, and accordingly the Upper Lias, the whole of the middle and upper division of the Jurassic formation, both lower members of the Chalk formation, the Neocomian and the Gault, are absent. The same rule holds for the whole of Northern Ireland, and this wide gap in the regular succession of the sedimentary strata is one of the most remarkable phenomena of the geognostic constitution of the country.

With respect to the Keuper, it was a novelty to me to learn that here this formation, as in Cheshire, and other parts of England, contains massive beds of rock-salt. In the neighbourhood of Carrickfergus, to the northward of Belfast, a rock-salt pit (Duncrue) has been worked for the last few years, from which, in the year 1873, there was obtained over 19,000 tons of rock-salt.

We should willingly have made a longer sojourn in this remarkable country, especially for the purpose of visiting the granite of the Mourne Mountains, south of Belfast, celebrated for their beautiful crystallized minerals. Our time, however, was up. The opening of the Meeting of the British Association in Glasgow, at which we were anxious to be present, was about to take place, and if we wished to avoid missing it, we were under the necessity, without delay, of embarking in one of the numerous steamboats plying between Belfast and that great Scottish industrial town.

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## III.—Across Europe and Asia.—Travelling Notes.

By Professor John Milne, F.G.S.;

Imperial College of Engineering, Tokei, Japan.

(Concluded from p. 37.)

### *Part IX.—Through China, Kalgan, Pekin, Shanghai.*

Contents.—Kalgan to Pekin—Geology of the district—Devonian Limestone—Coal Measures—Granite—Alluvium—Degradation of Steep Mountains. Pekin to Tiensin and Shanghai—Geology of the Country—Carboniferous Limestone—Granite—Alluvial Plain—Its origin by deposition of river mud and elevation. General Conclusion.

AFTER much slipping and sliding—for the small stream of water which flows down the pass had often glazed it from side to side—we reached the village of Yamborshan, just outside the Kalgan walls. Here I was well received by the Russian Postmaster, M. Shismaroff. This village, like Kalgan itself, is romantically situated in a defile, which is bounded by mountainous cliffs of a volcanic rock, called by Pumpelly a porphyritic trachyte. Before entering Kalgan, you pass underneath a gateway in the famous Great Wall of China. Right and left from this point, it rapidly ascends to the summit of the cliffs, which bound the defile, and its towers are seen standing on pinnacles of rocks, and looking over precipices from positions which seem inaccessible.

I left Kalgan on the 11th of December in a palanquin carried by two mules on the road towards Pekin. The first day, although I could see hills in the distance, I travelled over a flattish country covered with a deposit of sandy alluvium. In places, this formed gorges with perpendicular walls 30 feet in height. Next morning I crossed a boss of igneous rock, which was filled with veins of quartz and calcite. Soon after this I met donkeys and mules carrying coal, which told me I was entering a coal district. The first notice of this was a mountain of greyish limestone, along the side of which we travelled on a pathway cut out of the solid rock. After traversing across the ice, which spanned a flooded plain, we came to mountains of sandstone and shale, in which I saw several thin vein-like seams of coal. On the sides of these mountains we saw many old "dumps," marking the site of ancient surface workings.

In the afternoon I saw some pinkish-looking granitic mountains upon the left, and at this point the road became very stony, our course being everywhere impeded by beds of boulders. These consisted of porphyries, granites, felsites, and allied stones. Beyond this rough track, our road passed along by a wall cut in the alluvium which fills all the valleys, containing bivalve shells (*Cyrena*) to all appearances exactly similar to some which I obtained from an adjacent river.

Early next morning we entered the Nankan Pass, and after four hours' scrambling and sliding down over the bed of a frozen torrent, which was bounded by bare rugged granitic mountains, we reached the lower end of the defile, which, I think, presents the finest and most romantic scenery between Pekin and St. Petersburg. At the lower end of this pass, after passing the famous gateway of Küyungkwan, you see the junction of a limestone rock with the granite, the latter being overlain by the former. This limestone, together with that which I have before mentioned, is supposed to underlie the Coal formation, and to be of Devonian age—a view which is confirmed by the Brachiopoda which are said to occur in it.

The country at the lower end of the pass I found to be very bouldery, being covered with blocks of limestone and granite, which had rolled down from the mountains. These gradually became less and less, until we were at last upon a cultivated flat dusty plain, over which we travelled until we reached Pekin on the 14th.

I have not said more about my journey from Kalgan to Pekin, because this portion has been already described by Mr. Pumpelly in the Smithsonian Contributions to Knowledge, No. 202, in considerable detail, to which I have but little if anything to add.

When looking at high rugged mountains like those I had just passed through in the Nankan Pass, and like others which I had seen in other parts of the world, as, for instance, in N.W. Arabia, it often occurred to me that these mountains must be wearing away at an enormously greater rate than others do where the inclination is not so steep. Mechanical degradation, to which such mountains are subject, might be considered as roughly measurable by the action of gravity pulling particles to lower levels. A particle lying on a level plane is not affected by this action, and there is no degradation. But particles lying on inclined planes are pulled downwards, and the steeper the plane the greater is the pull, and consequently the more effective and rapid is the action. Thus, for instance, if we see a rock balanced on the side of a steep mountain, we know that there is more danger of its rolling down, and that when it does roll, it will do so more rapidly than if it had been placed upon the side of a hill which was comparatively less steep. This renders it dangerous to travel beneath a steep mountain, or through a deep cutting, and this is one way of looking at the recognized fact that steep mountains are degraded at a greater rate than those with slopes more gentle.

In order to gain some conception of what these rates are in comparison with the slopes upon which they occur, we must consider the conditions tending to accelerate or retard the downward pull of gravity. Amongst the many points to be considered when comparing the degradation or falling down of material upon two slopes, the following appear to be of importance:

1st. The force tending to loosen any material lying upon the surface of a mountain.

2nd. The circumstances under which material may obtain its initial motion.

3rd. The power that material when in motion has to roll to lower levels, and to disengage other matter that it may meet with in its descent.

Here we see three of the parts into which the subject divides itself, and each of these has to be considered relatively to slopes of varying inclination.

Part I.—The best way to look at Part I. is to take the simple cases of bodies lying upon inclined planes. The force tending to pull the body down such a plane is its weight ($W$), multiplied by the sine of the angle ($\alpha$) of the inclination of the plane, or $W \sin \alpha$; but as the inclination of the plane increases, $\sin \alpha$ also increases: therefore $W \sin \alpha$ increases. That is to say, if we have two bodies of equal weights on planes differently inclined, the force tending to pull the body down the steeper plane is greater than the force tending to pull the body down the plane which is less inclined.

The reason of thus stating a self-evident condition is for the purpose of comparing the relation existing between these forces on two different planes, which we see must be proportional to $\sin \alpha$. Thus if we take planes with slopes of 10°, 20°, 30°, 45°, 60°, and on each of these there rests a stone of weight $W$, the force tending to pull this stone down will be,

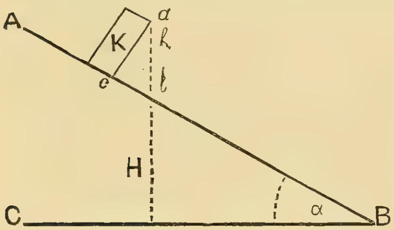
$W \sin 10°$, $W \sin 20°$, $W \sin 30°$, $W \sin 45°$, and $W \sin 60°$,
or $W \cdot 173$, $W \cdot 342$, $W \cdot 500$, $W \cdot 707$, $W \cdot 866$.

From these few cases we see that for low slopes, say up to 30°, the force tending to pull the stone downwards increases approximately proportionately to the angle; that is, for double the inclination you get double the force; but on slopes of a steep inclination, as compared with those of a low inclination, this rate of increase is not so rapid; thus the force tending to pull a stone down on a plane of 60° is not six times the force tending to pull a stone down on a plane of 10°.

This result will be much more strikingly illustrated if we take into account the initial resistance to motion, where the force at starting will be $W \sin \alpha - \mu W \cos \alpha$, $\mu$ representing the initial resistance to motion, whether it is of the nature of friction or the resistance offered to the breaking off of rocky masses.

Part II.—Before considering the effect that matter has when in motion down an incline, we must recognize the fact that a stone when it obtains motion upon a steep mountain, as in falling from a rock, the rolling over of a stone usually would obtain more Kinetic energy at its start, than one upon a mountain of less inclination would.

Thus upon an inclined plane $AB$, a particle falling from the summit of a rock $a\,c$ to the point $b$ upon the plane $AB$, would usually have a much greater height to fall upon a plane of steep inclination, than it would upon one where the inclination was more moderate, and therefore at its starting to roll towards $B$, would also have more energy.




Calling $a\,b = h$; $a\,c = K$; the inclination of the plane $= \alpha$; then $h = K \sec \alpha$, from which we see the rocks upon two different planes being similar, or $a\,c$ being constant, then this height varies as the secant of the angle of the inclination of the plane. Therefore a rock thus starting in a manner analogous to that considered, either by tumbling forward or actually falling, has at the commencement of its course more energy to do work as a stone in motion—this energy varying as the secant of the angle of inclination of the plane.

Part III.—The power that a stone has in rolling to lower levels and overcoming obstacles in its passage over the sides of two mountains which differ only in inclination, might be compared by the distance they relatively travel. It is evident one on a steep slope would tend to roll farther than one on a gentle slope, and the vertical distances down which these blocks would travel before coming to rest would measure the relative rates of this sort of degradation,—because the mountain which rolled its material farthest down would tend to become level the quickest.

Now taking the same figure as that illustrating Part II., and imagining a body of weight $W$, in motion at the point $b$, due to its fall from $a$, and rolling to $B$, that is, descending through the vertical height marked $H$.

Let $\mu$ be the resistance opposed to sliding and rolling of the body down the plane. If the body meets many small obstacles in its path, this will be analogous to a frictional resistance.

1st. Owing to its initial velocity, the body will have at starting from $b$, an energy measured by $\frac{1}{2}\frac{WV^2}{g}$, but $V^2 = 2gK\sec\alpha$ $\therefore$ $\frac{1}{2}\frac{WV^2}{g} = WK\sec\alpha$.

2nd. The work done by gravity upon the body through the vertical distance $H$, is measured by $WH$.

3rd. The work done against friction is $\mu W\cos\alpha\, H\operatorname{cosec}\alpha = \mu WH\cot\alpha$.

Now when the body comes to rest rolling down the height $H$, its power of doing work must have been absorbed, or is equivalent to the work done against frictional resistances,

$$\text{Therefore } WK\sec\alpha + Wh = \mu WH\cot\alpha$$

$$\text{Whence } H = \frac{K\sec\alpha}{\mu\cot\alpha - 1}$$

Taking the angles

$10°$, $20°$, $30°$, $45°$, and $60°$, where for the sake of example let $\mu = \frac{1}{2}$

then $H \propto \underline{\cdot 55}$; $\underline{2 \cdot 8}$; $\underline{\infty}$; $\underline{\infty}$; $\underline{\infty}$.

That is to say, bodies on planes with an inclination above 30°, where the resistance to rolling was only half the weight, would roll on until they reached the base of the plane, whatever its length might be, getting faster as they descended; whereas two similar bodies on planes only differing in their inclinations being respectively 20° and 10°, the body on the plane of 20° would roll more than *four* times as far down as the one on the plane of 10°.

Taking another case, where $\mu = \frac{3}{4}$, and the planes remaining the same,

$H \propto \underline{\cdot 31}$, $\underline{1}$, $\underline{3 \cdot 9}$, $\underline{\infty}$, $\underline{\infty}$.

Now it is clearly seen that as $\mu$ might be much greater than $\frac{3}{4}$, the action is probably much more intensified than it is here shown. It is also easy to see that if we take into account the probable mechanical action of water in detaching stones and other possible agencies, the action would also be more intensified than is indicated by the above numbers.

It is evident, however, that no mechanical theory can take into account the infinite number of phenomena which really occur; nevertheless these considerations will perhaps give an idea of some important circumstances which affect the rates of degradation of steep mountains.

After more than a week's rest, I left Pekin on the 24th, my destination being Tiensin. This occupied two days. The country travelled over was an open flat loamy plain, similar to that which I crossed when entering Pekin. At Tiensin I found the river still closed by ice, and if I intended travelling to Shanghai by steamer, I should have several weeks' delay. This being the case, I determined to travel overland in mule carts, a journey which I was told would occupy about twenty days. It was the 5th of February before everything was prepared for the journey, and at 12 o'clock on that day, in company with a Russian officer, Colonel Unterberger, who also wished to reach Shanghai as quickly as possible, I started off on a trip of new experiences.

For the first six days we rattled along over a continuation of the Tiensin and Pekin plain. With the exception of a few canal banks, mud walls of villages, and fences round fields, everything is painfully flat. Every step one takes raises a cloud of dust, which, when the wind is blowing, becomes unbearable. At times this was so thick that you appeared to be surrounded by a fog, and on one occasion it was so bad that a midday halt was called, and we sought refuge in an inn, where we remained until next morning. The fine impalpable dust, which is raised in clouds at every puff of wind, indicates the nature of the loam with which these plains are covered, and also tells us something of its origin, which was probably as a sediment from the flooding of some large river. The fresh-water origin of these plain deposits has often been before referred to, a view which is confirmed by shells I found in it above the Nankan Pass, and afterwards in Shantung. These were *Cyrena* and a *Helix*, and in the more recent river deposits, *Glaucomya* and *Anodon*.

Mr. Pumpelly, in the paper to which I have before referred, speaks at length about somewhat similar sediments to these which he considers to have been deposited in a chain of connected lakes. Unfortunately his explanation of the origin of these lakes is very vague, what he says being that it is probably to be sought in the dislocation forming the plateau wall to the north of them, the descent of the land previous to that event having probably been toward the Gobi, in which direction also the Yellow River flowed, if it existed at that time. How far this lake theory may be applied to districts covered with alluvium lying far back in the interior of China, as in Ordos, the land lying in the northern bend of the Hwang Ho, or to the deposits in Hupeh on the Yangtse, I am unable to say; but certainly those deposits which I saw when crossing the provinces of Chihli and Kiangsu would, from their position alone, forbid such a supposition. As Mr. Pumpelly tells us, they appear undoubtedly to represent a delta-plain. The river which formed this plain is the Hwang Ho, which has been partly assisted by the Yangtse. Looking at any ordinary atlas, it will be seen that the Hwang Ho now discharges itself into the Gulf of Pechihli, on the northern side of Shantung; whilst its old course is marked by dotted lines, showing that formerly it discharged itself into the Yellow Sea, nearly 500 miles farther to the south. This change took place between 1859 and 1860, when a breach was made in its banks 30 or 40 miles south of Kai-fung-fu. This may have arisen from the banks having been neglected, or it may have been done purposely to prevent the advance of troops, it then being the time of the Taiping rebellion. How easily this river could devastate a country, I readily perceived on reaching its banks, which was on the 11th of February, the same day that I saw the mountains. At this point, which was near the city of Chi-ho-hsien, the breadth of the stream must have at least been from 300 to 400 yards. It was apparently very low, and at least 25 feet below water marks in banks on either side by which it was bounded as if between two walls. These banks extend as ridges across the surrounding flat country, and it was not until we climbed to the top of them that we could see anything of the water, which was rapidly flowing along as a muddy stream at the rate of about 200 feet per minute. This rate was calculated by walking down the banks, and keeping pace with blocks and pans of ice which were being carried down towards the sea. At present, during flood-time, the waters of this river must, I think, be above the level of the surrounding country. In its old course its bed, which I subsequently walked across, was above this level. In the course of years, by the deposition of part of the sediment with which its waters are ever densely charged, the bottom of the new course will be similarly raised. As the bed is thus raised, the waters rise, and the inhabitants have either to raise the banks or else suffer from inundation. The case is analogous to portions of the River Po in Italy. Man struggles against the vast accumulation of sediments by the waters of these great rivers, but every now and then they break through their bounds and show themselves victorious. Large numbers of workmen are employed to maintain these banks, and should these neglect their duty, or be withdrawn by a chief wishing to appropriate the funds entrusted to him for the carrying out of these works, a calamity results, which, for the destruction of life and property, is unparalleled. In times of war breaches have wilfully been made in these banks, and conquests which were almost instantaneous have been effected.

In this way, by accident or intention, the Hwang Ho has often devastated the surrounding country with floods, and made great changes in its courses. Mr. Pumpelly gives ten maps illustrating the different channels this river has had since the year 602 B.C. These changes appear to have been as follows, the table showing the number of mouths entering into the Gulf of Pechihli and the number entering the Yellow Sea.

| | Yellow Sea. | Gulf of Pechihli. |
|---|---|---|
| 1. From the time of Yu down to 602 B.C. | One | Three |
| 2. During the Chow Dynasty, 602 B.C. | None | One or perhaps two |
| 3. Third century B.C. | One | Perhaps one |
| 4. About 132 B.C. | None | One or perhaps two |
| 5. About 11 B.C. | None | Two |
| 6. From A.D. 70 to A.D. 1048. | None | Two |
| 7. From A.D. 1048 to A.D. 1194. | None | Two |
| 8. Under the Kin Dynasty. | One | Two |
| 9. Under the Yuen (Mongol). | One | One |
| 10. At present. | None | One |

At each of these periods there is record of a great change having taken place in the course of the river, the alterations not only as to the sea into which it flowed, but also in the direction of its channel, having been very great. When it flowed by one branch into the Yellow Sea, and by one branch into the Gulf of Pechihli, its lower course might be represented by the letter Y, between the forks of which was situated the rocky province of Shantung, round the back and along the sides of which these alluvial plains extend. The fact that the Hwang Ho often changes its course, and in doing so floods the country, and that but for the interference of human agency this would be of more frequent and continuous occurrence, together with the relation its branches hold to the province of Shantung, are circumstances which must not be overlooked when considering the origin of the great plain of Eastern China.

The quantity of sediment brought down by this river must be, from what I saw, very great. Barrow estimates it as being 2,000,000 cubic feet per hour. This quantity of material being continually deposited near the mouth of the river, naturally tends to shallow the ocean and to increase the present extent of the delta. As an example of this increase, Mr. Pumpelly tells us that "in B.C. 220 the town of Putai is said to have been one *li* west of the sea-shore, while in A.D. 1730 it was 140 *li* inland," which is equivalent to a yearly increase of about 100 feet.

Taking this with the facts already mentioned, we can readily carry ourselves back to the time when the mouths of the Hwang Ho, and with them the sea-coast, were much farther inland than they are at present, and the province of Shantung was lying out at sea like a rocky island. Since then there has been a gradual deposition of material going on, and the coast-line has been encroaching on the sea. What is more, I believe it probable that this action may have been augmented by the operation of a slow elevation. The possibility of an old sea-margin, although not advocated, is indicated by Mr. Pumpelly as perchance existing, from the fact that the arms of the Hwang Ho have not approached the western mountain border of the plain. Taking this in conjunction with the evidence of recent elevation existing in surrounding countries like Japan and Siberia, that there has been such an elevation, although by no means proved, is shown to be within the pale of probability.

After crossing the Hwang Ho, we ascended the slope towards the Shantung hills, which we had seen before us. In doing so, we passed through several defiles in the alluvium which flanked their sides. This alluvium, instead of being a homogeneous mass of consolidated silt, like that we had been crossing in the plains, now contained pieces of limestone and fragments of other rock, evidently derived from the hills upon which it lay. The same processes of degradation had in times gone by, just as at the present day, been occupied in moving the detached stones of the hills towards a lower level. On reaching the region where silt was being deposited, they were gradually covered up and buried, and in this way no doubt the greater number of stones we saw in the alluvium arrived in their present position. On the sides of the hills before us, and stretching up their valleys, we could see terraces of ground which had been formed for purposes of cultivation, reaching up to the very limits of the alluvium. As we ourselves gradually ascended towards this limit, the loam grew thinner, and assumed a slightly reddish tint. This colour I fancied due to the strata of these parts having been deposited in shallow water, where, by the action of the air and the sun's warmth, oxide of iron was more readily deposited than it would have been in deeper water, not containing so much oxygen, or being so near its source. I noticed a case of this sort actually in operation along the gravelly shores of the river Tom in Central Siberia. On a smaller scale it may be seen around the edges of ponds or even puddles where the water is at all chalybeate—an analogous phenomenon being produced in the chemical laboratory when solutions containing iron are being evaporated.

After passing the village of Kaisa, we were fairly amongst the hills, which were grey and rugged, half their surface being covered with grass, and the other half bare rock. Judging by the stones beneath our feet, and from the rocks which here and there cropped up, these hills apparently consist of a bluish-black hard limestone, which, from its resemblance to that I passed before reaching the Coal-fields lying to the North of Pekin, and from the fact that Coal is likewise found in this neighbourhood, I should be inclined to think was also of Carboniferous or else of Devonian age. The strata, which in many places are distinctly visible, have a slight dip of about 1° towards the north.

In many places amongst these mountains we passed through narrow defiles in the alluvium. These seem to have been cut down through the alluvium which fills the bed of these valleys chiefly by the agency of traffic. They could be seen in all stages from mere rut marks to deep cuttings flanked with perpendicular walls 40 and 60 feet in height. When in these latter, looking up at the loose material above you, charged with stones ranging from small pebbles to huge boulders, you could not but speculate on the risk incurred by passing travellers. Some of these defiles were so narrow that we had to wait until the line of wheelbarrows, carts, and people, which are as thick upon these country roads as they are upon a market-day in a country town at home, going in a direction opposite to that in which we were travelling, had passed out before there was room for us to enter. In the mountain wadies of North-western Arabia I have noticed the formation of cliffs of earth which are very similar to these in China. The growth of these truly perpendicular walls in Arabia appears to result from the undermining action of the little water which sometimes trickles down these wadies, together with that produced by a sand-drift which is ever working along their lower portions. When this has gone on for a certain distance, the superincumbent material, having little or no lateral attachment to the contiguous mass, falls down. There being nothing in the material to produce an unequal disintegration, should it commence at any one point, it is at once carried very rapidly over the surface of the plain in which it commenced, the materials being so loosely placed together that they are mutually dependent. Similar causes no doubt aid in the formation of the Chinese gulleys. Those which run back towards the mountains as tributaries to these main arteries of traffic have no doubt also been hollowed out by the action of water, which, commencing at the bottom of the valley, worked its way backwards up towards the hills, much in the same way that a waterfall acts upon the face of rock over which it drops.

Next morning at 8 A.M. (Saturday 12th) we reached a point where the limestone ended and gave place to granite. With this change, both hills and roads were rougher. About 12 o'clock we crossed the water-parting, and apparently the axial line of the granitic nucleus. In the afternoon we passed Tainan, a large and compact town, beautifully situated beneath a high rugged clump of granitic mountains. Beyond this town we emerged upon an open plain, and we were not a little pleased to be relieved for a time from the rough jolting we had been undergoing in our springless carts over bouldery roads.

The occurrence of granitic rocks in this portion of Shantung, coupled with what has been observed further to the north-east, as, for instance, near Cheefoo, would indicate that this province has altogether an axis of granite rather than one partly of Devonian Limestone, as indicated upon Mr. Pumpelly's "Hypothetical Map of the Structure of China."[1] Although we now travelled upon a plain, high mountains yet remained both upon our right and left. That night we crossed the river Van Ho. It was about 100 yards broad, and deep enough to reach the axle-trees of our waggons.

Next morning, Feb. 13th, we bent our course towards the east, and turned up a slope on to a low part of the hills, which upon the previous day had been upon our right. These were granitic, and round and undulating in outline, reminding me in contour of some of the mining districts in the vicinity of Land's End in Cornwall. From the materials used in building houses and walls in this district, I think that, in addition to the granite, limestone must also occur. The ground around was, however, covered with quartz and degraded felspar, the result of the decomposing granite. During the afternoon our course was S.S.E. along a plain six or eight miles broad, bordered right and left by hills, which were partly limestone and partly granitic. The limestone hills were seen first upon our left, but afterwards upon both right and left. These dipped at about 15° N. About 5 P.M. our road led us over a ridge of earthy red beds, which dipped at 10° N.W. Disseminated through them were nodules of white calcite.

All next morning (14th Feb.) we travelled over limestone projections, and boulders produced by weathering, which made our road so uneven, that we could not remain in our carts. A large town called Moiinshan, which we passed, had walls built out of this grey limestone. I also noticed blocks of conglomerate, and a

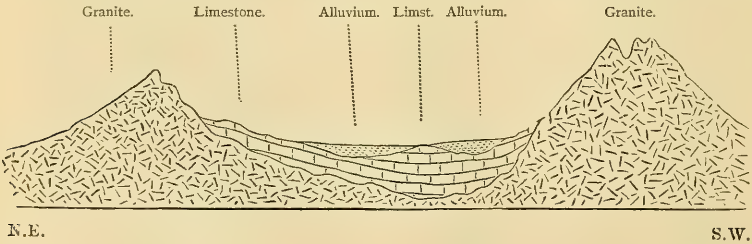



*Diagram.*—Section across the valley near Dowdjoa, Shantung. The mountains are granite, the floor of the valley is limestone, with a superficial covering of alluvium.

[1] See Contributions to Knowledge, No. 202, of the Smithsonian Institute.

reddish sandstone. On our left we still had hills consisting of a yellowish grey limestone dipping S.E. at 10°. Farther on, the limestone became blackish, then shaly, and afterwards pinkish. This limestone is not so hard and cherty as that which I saw when entering the Shantung mountains. About midday, near Dowdjoa, the granite again commenced, both upon our right and left. On this the limestone appears to rest, and on that again the alluvium, as illustrated in the accompanying section taken from N.E. to S.W. across the valley down which we were journeying.

During this part of our course we crossed the sandy beds of many small rivulets, which either found their way through a gap in the mountains upon our right, or else joined a stream running parallel with us.

Next day, Feb. 15th, the country appeared rapidly to be growing flatter. After passing Pinghaho, within the distance of a mile, we crossed the successive outcroppings of the following four beds :—

1. A volcanic rock forming a rounded knoll.
2. A Red Quartzose Sandstone.
3. Beds of Black and Yellow Shales, which were very thin, fissile, argillaceous and slightly calcareous.
4. Overlying all the above, a highly Calcareous Sandstone, which, being harder than number 2 or 3, stood above them as a small ridge.

These rocks, which strike N.E. and S.W. and dip 10° E., from their lithological resemblance to the rocks of the Coal-measures, I take as belonging to that formation, as indicated in Mr. Pumpelly's map, to which I have before referred. About half an hour after passing these beds, I saw the outcrop of a porphyry containing large crystals of felspar, which was immediately followed by a granitic country traversed by quartz veins stained with iron oxide.

At 2 o'clock in the afternoon we forded a large stream, 50 yards broad, running towards the south-east, and immediately entered the large town of Ejow.

At 6 o'clock in the evening we forded a rapid river running to the right, called the Yee Kai, and entered the town of Yee Kai San, where we remained for the night.

Next day we were fairly out upon the open alluvium plains, and the only hills we could see were some very low ones, away upon the western horizon. On Thursday, the 17th February, we crossed the gravelly bed of an old river which must have been 200 yards in breadth, and, from the direction in which the sharp edges of the piers of an old bridge were yet standing, must have run to the left. On Friday the 18th, we travelled a short distance along the embankment of a canal about 50 yards broad and running east. About midday we walked through the embankments and across the old bed of the Hwang Ho, which is now under cultivation, immediately afterwards entering the town of Tsingkianpu, where we left our carts and engaged a boat upon the Grand Canal. The stream being with us, and the wind favourable, we travelled rapidly. On Monday we passed a breach in the right bank, and obtained a view of the Lake Koieokho. This lake is about 15 feet deep, and is connected with the canal, which, at this point, is itself only $2\frac{1}{2}$ to 3 feet in depth.

On Tuesday, the 22nd February, we reached Chingkian on the Yangtse, where we were fortunate in meeting a steamer, which next morning landed us in Shanghai, after a quick trip of 19 days since leaving Tiensin; six months and three weeks since leaving England. This latter section of my journey through half the length of China, although not so trying as the trip I had just experienced in Mongolia, was both tedious and disagreeable. Everywhere one was followed by crowds of people, who called one a "foreign devil." Sometimes we were refused admittance at the inns, and had, in consequence, difficulties in finding lodgings. We had to travel from before sunrise, often 4 A.M. until after sunset, in a springless vehicle, drawn generally at a trot over rough roads. These facts alone, without the enumeration of others, will at once be recognized as being sufficient to render observation almost an impossibility.

The first part of this journey from Kalgan to Pekin has been described by Mr. Pumpelly, who made many excursions in the neighbourhood of these towns, and my scattered notes are only confirmatory of what he has already written.

On the remainder of my journey between Pekin, Tiensin, and Shanghai, my observations, although fragmentary, may be useful as giving a general idea of the structure of this portion of China, and adding something to its geological cartography.

The provinces traversed were Chihli, Shantung, and Kiangsu. Shantung, which runs from N.E. to S.W., appears to have a central axis of granite. Flanking this, upon the S.E., there are limestones, shales, and sandstones, and upon the N.W. limestones. A portion of these latter may be Devonian, but the remainder, together with those upon the S.E., are probably Carboniferous. These formations make Shantung a mountainous province, and give a character to its natural products and to the industries of its people.

Lying round this, from the shores of the Pechihli Gulf on the north, extending as a semicircle down to the Yellow Sea, are plains of alluvium representing a delta formation of the Hwang Ho.

*Conclusion.*—After arriving at Shanghai, I took a ship to Japan, where I arrived on the 8th of March, 1877, after seven months and seven days travel, which brought me fairly to the limit of the subject embraced under the title of this paper, "Across Europe and Asia."

The land journey between St. Petersburg and Shanghai was more than 6000 miles, 4000 miles being through Russia and Siberia, 800 miles through Mongolia, and about 1000 miles through China. Considering the distance travelled, and the time occupied upon the journey, it is unsatisfactory to look at the little information bearing on geology which I was enabled to collect. The chief cause of this was from the fact that it was imperative that I should always be moving, not only during the day, but also very often during the night. Not knowing the language of the country in which I travelled, precluded me from inquiry. Again, many districts, like the Siberian Steppes, presented a monotonous sameness throughout their area, whilst the least known, and, I believe, the most interesting, section of my journey in Eastern Siberia and across Mongolia, not only was everything buried in snow, but the cold was so intense that I could do little more than attend to personal requirements. In China, the chief detriment to the making of observations was the rapidity of travel, which prevented any deviation from the track, coupled with a rude and ignorant inquisitiveness displayed by the inhabitants, from whom there was no escape.

These circumstances will, I think, sufficiently explain the meagreness of my notes, and at the same time the origin of any inaccuracies should they perchance be found to have unobservedly or unwittingly crept in. Here and there upon my journey, especially in Siberia, I found friends who endeavoured to exchange ideas; but unfortunately, with but few exceptions, I found my ignorance of Russian usually prevented my obtaining a tithe of what I might otherwise have learnt. Whilst subsequently writing out these notes, being without the means of reference may in all probability have caused me to put forth arguments either for or against which there may be much evidence yet remaining to be adduced. In several instances my arguments have been antagonistic to the existence of polar ice-caps, but this has only been in regard to the production of certain phenomena. All that I endeavoured to show is, if these mighty engines existed, their traces must in many cases have been subsequently obliterated, and what is more, many of the so-called glaciated regions of the world I believe to have been produced by coast-ice acting on a rising area.

When speaking of the origin of the Siberian Steppes, as in the case of the glaciated rocks I saw in Finland, I have endeavoured to explain their origin by existing agencies rather than referring to those the origin and action of which were more debatable.

What I said of the earthquakes of Eastern Siberia I gathered in part from an epitome which is given of them by Messrs. Orlof and Shtuikin in the Siberian Calendar for 1875.

The remainder of my information was gathered from personal observation or from persons more or less conversant with the subjects on which I have written, to all of whom I think I have before referred, and whom I now take the opportunity of kindly thanking.

It therefore only remains for me to put my fragmentary jottings forth to be sifted, arranged, and taken for their worth. In some cases I may have been mistaken in my observations, or have overestimated their worth; but where this is so, feeling my fallibility, I hold myself open to conviction.

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## IV.—On the Preservation of Deposits of Incoherent Materials under Till or Boulder-clay.

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

THOSE who maintain that Till or Boulder-clay has not only originated but accumulated underneath glacier-ice may sometimes have felt puzzled to account for the preservation of beds of more or less incoherent materials below a deposit which they have so many cogent reasons for believing to be a true *moraine profonde.*

How could such loose stuff as gravel, sand, and silt withstand the grinding action of a superincumbent ice-sheet? And how, if these deposits have been thus traversed by ice, can we reconcile that with our belief in the excavating power of an ice-sheet? This, indeed, is the principal objection urged by Mr. S. V. Wood and others who deny altogether that Till or Boulder-clay has been amassed below ice. They deem it quite impossible that an ice-sheet could pass over such beds as I have referred to without obliterating them; and having assumed so much (for, of course, it is solely upon their preconceived ideas as to how a great ice-sheet would behave, that their objection is based), they find no difficulty in concluding that Till could not have been accumulated under ice, and that the occurrence of Till resting upon beds of gravel, sand, and clay, is no proof whatever of the former passage of an ice-sheet. In this short paper, however, I do not mean to enter upon the question of the mode of formation of Till. Quite enough ink has already been shed upon the subject. Every day supplies me with fresh evidence in favour of the view which I support—namely, that Till has not only been formed but also accumulated under an ice-sheet; and I am not aware of any phenomena which this theory of the origin of Till fails to explain, although very many facts are known to me which are quite irreconcilable with any other view. My object at present, however, is not to point out the inadequacy of other theories and hypotheses—in doing which there would necessarily be much repetition of many unanswered arguments—but simply to show that a strong and well-grounded belief in the erosive power of ice is quite consistent with an equally firm conviction that in many cases thick masses of ice have crept over beds of gravel, sand, silt, clay, and peat. The one persuasion is no more contradictory to the other, than a serene confidence in the denuding powers of running water is opposed to the belief that the same water also deposits and accumulates detritus while it flows. One may surely hold that a certain deep ravine or glen, in the upper part of a river-valley, has been excavated in the course of ages by the stream one sees at the bottom, and at the same time assert, without the fear of being considered self-contradictory, that the broad alluvia (overlying, it may be, incoherent marine strata), in the lower and more open reaches of the valley, have been deposited by the very same river that dug out the deep ravine above. What I and others, who hold with me, maintain is simply this: first, that, in regions where the erosive action of the ice-sheet was great, little or no Till was allowed to gather, and rock-basins were scooped out, when the nature of the ground was favourable to that end; and secondly, that, in places where the grinding-power exerted was less, thick Till frequently accumulated, and subglacial and interglacial beds were often preserved.

Our ice-sheet flowed, we cannot doubt, with a differential motion: it must have moved faster in some places than in others. In steep valleys and over a hilly country its course would often be comparatively rapid, but very irregular—lagging here, flowing quickly there —while in wide, open valleys that sloped gently to the sea, such for example as those of the Forth and the Tweed, the whole body of the ice would flow with a slower and more equable motion. As the ice-sheet approached its termination, more especially if that terminus chanced to be upon a broad and comparatively flat region, like East Anglia, the erosive power of the ice would become weaker and weaker for two reasons: first, because of its gradual attenuation, and secondly, because of its constantly diminishing motion. These, in a few words, are the varying effects which one might *à priori* infer would be most likely to accompany the action of a great ice-sheet. And an examination of the glacial phenomena of this and other countries shows that the actual results are just as we might have anticipated, had it been previously revealed to us that a large part of our hemisphere was, at a comparatively recent date, almost entirely smothered in ice. In places where, from the nature of the ground, we should look for traces of great glacial erosion, we find rock-basins; in broken hilly tracts, where the ice-flow must have been comparatively rapid but irregular, and the glaciation severe, we meet with *roches moutonnées* in abundance, but with very little Till; in the open lowlands and in the broad valleys where the ice-sheet would advance with diminished but more equable motion, we come upon widespread and often deep glacial deposits, and now and again with interglacial beds; while over regions where the gradually decreasing ice-sheet crawled slowly to its termination, we discover considerable accumulations of Till, often resting upon apparently undisturbed beds of gravel, sand, and clay.

*The distribution of interglacial deposits, therefore, is really in itself a proof that they have been overridden by ice.* When they occur in highly glaciated regions, it is only as mere patches, which, occupying sheltered places, have been preserved from utter destruction. In the opener low grounds they are found in greater force, although in such places they almost invariably afford more or less strong evidence of having been subjected to much erosion and crumpling. But the further we recede from the principal centres of glaciation, and the nearer we approach the extreme limits reached by the ice-sheets, the more extensive and the less disturbed do interglacial deposits become. In a word, they occur in best preservation where the erosive power of the ice was weakest; they are entirely wanting where we have every reason to believe that the grinding force was strongest.

If we look at the interglacial beds themselves with any attention, it is very rarely indeed that we shall not find proof of their having been subjected to more or less crushing and erosion. The overlying Till cuts into them again and again—they are often caught up and involved with the Till—and crumpling and contortion are frequently conspicuous. No one who has paid much attention to glacial matters will doubt that all this powerful erosion and confusion are due to the passage of ice over the beds. It may be taken as proved, therefore, that an ice-sheet does under certain conditions ride over incoherent deposits of gravel, sand, silt, clay, and peat, without entirely obliterating them. But all interglacial beds, even in highly-glaciated Scotland, are not equally crumpled and contorted. Occasionally the layers of sand and laminated clay lie quite horizontal, even when the Till cuts down, as it were, to the depth of 20 feet and more into the stratified deposits. We have, therefore, further proof that ice may roll its bottom-moraine over incoherent deposits without disturbing the horizontality of their bedding, although at the same time these same deposits may here and there be abruptly cut out and truncated.

If such has taken place in the valleys of a well-glaciated country like Scotland, it surely cannot be unreasonable to infer that in a less ice-worn country, in a region where the ice was not so thick, and where its motion was slower, interglacial beds should be much better preserved. If the ice has spared, in hilly Scotland, interglacial deposits that range in thickness from a foot or two up to twenty yards and more, where is the improbability of its having overridden much thicker and more continuous deposits in those low-lying parts of England where it approached its termination?

And here I may remind geologists of one among many equally suggestive facts, connected with the distribution of interglacial beds in Scotland, that while we have indubitable evidence of a submergence of the land, during the last interglacial period, to an extent of upwards of 500 feet, the marine deposits of that date have yet been all but entirely swept away from the higher levels and more exposed parts of the country—there being only one place where they are met with so high up as 500 feet. It is not until we get down to the low country—to the wide open valleys, and to the borders of some of the great friths (which are merely submerged valleys)—that we find the relics of the marine stage of the last interglacial period coming on in force. An excellent example of this peculiar distribution of interglacial marine deposits came before me recently in the Outer Hebrides. Interglacial beds are met with in two places in the Long Island, namely, at Ness and in the Eye Peninsula. The highest point attained by these deposits is about 200 feet above the sea. They rest upon an eroded surface of Till, and are themselves overlaid by a second or upper Till, underneath which they show a most irregular surface, as a rule, being cut into by the Till and crumpled, contorted, and confused. In other parts of the same cliff-sections, however, they show little or no disturbance at all, but the Till rests upon them apparently quite conformably. In the Eye Peninsula they occur as a mere local patch, which exhibits all the appearance of having been scooped and ploughed out—the clay being abruptly truncated, and overlaid by red Till. When these interglacial beds were accumulated, all the low grounds of Lewis, up to a height of 200 feet at least, must have been submerged—and this submergence could hardly have been local and confined to Lewis, but extended in all probability to the whole Outer Hebrides. Where, then, we may well ask, are the marine deposits which must at one time have cloaked these low grounds—where are the clay-beds and sandy deposits and beach accumulations which must have been laid down contemporaneously with the interglacial beds at Ness and Garrabost? The low grounds in question are sprinkled solely with Till, and dotted with morainic rubbish and erratics. Instead of marine deposits, we see only the marks of a recent and severe glaciation. Every vestige of the last interglacial occupation by the sea (with the two exceptions mentioned) has been swept away by the ice-sheet, whose bottom-moraine was rolled over the shell-beds at Ness and Garrabost. And the principal mass of these deposits occurs in the very position where, as I shall have occasion to point out more particularly in another place, the ice-sheet must necessarily have exerted less grinding power.

I have drawn attention elsewhere to certain remarkable facts connected with the distribution of interglacial beds in North America, and have pointed out that the researches of our fellow-labourers in the States and Canada have proved that American interglacial deposits occur in the same peculiar manner as our own:—they are absent or very rarely met with in the regions north of the great lakes, and they increase in importance as they are followed south. Quite recently Mr. G. Jennings Hinde, of Toronto, has described some very interesting and important sections, which are exposed upon the shores of Lake Ontario.[1] These sections show no fewer than three separate beds of Till with intervening stratified deposits, the lower one of which has yielded many plant-remains and fresh-water organisms. The section extends continuously along the shores of the Lake for a distance of nine miles and a half, and the fossiliferous interglacial beds attain a thickness of 140 feet. Occasionally they are violently contorted and confused, and in one place the overlying Till cuts down into them to a depth of more than 100 feet—the breach occupied by the Till being about 450 yards in breadth. Yet throughout the greater part of the section this overlying Till rests apparently quite conformably upon the stratified deposits, which then show perfectly horizontal and undisturbed bedding. Here, then, we have a case where one and the same ice-sheet has ploughed out incoherent strata, driving a deep and broad trench through them, although here and there it has allowed them to escape with only severe crumpling, contortion, and confusion, while in yet other places it seems to have rolled its bottom-moraine quietly over their surface in such a way as to leave the beds apparently undenuded and undisturbed.

The same geologist writes me that "up to the present time these interglacial clays, etc., appear to occur only in the lake-depressions and other localities at low levels. I cannot find them in the more elevated districts, and supposing a fresh glacier now to creep over this country, it would sweep before and beneath it the Till on the uplands, and cover over the stratified clays in the present lakes with this material; and there would thus be a repetition of the same arrangement of stratified beds and overlying Till as is now seen in the present cliffs facing the lake." He thinks that the earliest ice-sheet had more grinding power than the ice-sheets of later cold

[1] Canadian Journal, April, 1877.

periods; but the Till that overlies the fossiliferous interglacial beds, indicates nevertheless, the former presence of a very considerable ice-sheet, for the beds which it has spared are the mere fragments of what must have been widely extended deposits covering a broad region, from which they have since been entirely removed.

Mr. Hinde tells me also that he has just discovered plant-remains in a similar position near Cleveland, Ohio. The deposits at this place are described by Dr. Newberry as his "pebbly Erie clay." They consist, my correspondent says, first, of Till at the lake-level; secondly, of about 48 feet of sand and loam, containing a layer of plants; and thirdly, of good unstratified Till full of striated stones, —six feet thick. The interesting point about this section is the occurrence of plant-remains in beds that belong to Dr. Newberry's "laminated clay series"—a series which that able geologist has described as unfossiliferous, and never overlaid by Till.

I might easily refer to many examples of similar phenomena in the glaciated districts of Northern Europe, to show that the distribution of interglacial beds is the same there as in our own country and North America. But I need not enter further into details at present. It is enough for my immediate purpose to have again pointed out that, in considering the origin of glacial and interglacial deposits, it is needful that we pay more attention to the distribution of these beds than we have hitherto done. This is the direction in which, as it seems to me, we must look for the key to the whole mystery; indeed, I do not see how otherwise we are to arrive at any reasonable explanation of the phenomena. At the first blush it may appear hard to believe that a great mass of solid ice could ever pass over the surface of incoherent deposits of clay and sand. But the appearances presented by these deposits tell their own tale, and teach us, as we have been taught before, that our preconceived notions of what Nature's forces can and cannot do are often enough wide of the mark.[1]

It is needless to refer one to the petty glaciers of the Alps and Norway to prove that glacier-ice cannot both erode its bed and accumulate *débris* upon that bed at one and the same time. A mountain-valley glacier is one thing—a glacier extending far into the low grounds beyond the mountains, and, it may be, coalescing with similar extensive ice-flows, is another and very different thing. No considerable deposit could possibly gather below alpine glaciers like those of Switzerland and Norway; but underneath glaciers of the kind that invaded the low grounds of Piedmont and Lombardy we know that thick deposits of tough Boulder-clay, crammed with scratched stones, did accumulate; and not only so, but that *these glaciers flowed over incoherent deposits of sand and clay containing marine shells of late Tertiary age, without entirely obliterating them.*

[1] It may reasonably be doubted whether interglacial deposits were always so very loose and incoherent at the time they were overridden by ice. My brother has suggested that when the ice-sheet advanced over a land-surface, the loose superficial deposits might be frozen so hard as to be capable of resisting a very considerable degree of glacial erosion.

The deposits referred to occur now as little patches within the area bounded by the great terminal moraines.

As physicists themselves are not yet quite agreed upon the subject of glacier-motion, it is not incumbent upon the geologist to explain the precise mode in which a thick mass of ice can creep over the surface of incoherent beds without entirely demolishing them. It is enough for him to show how the remarkable distribution of the interglacial beds, and the various phenomena presented by these deposits, indicates that ice *has* overflowed them. It is useless, therefore, to tell him that the thing is impossible. The statement has been made more than once that an ice-sheet several thousand feet thick is a physical impossibility, but unfortunately for this dictum the geological facts have demonstrated that such massive ice-sheets have really existed, and there appears to be one even now covering up the Antarctic Continent. We used also to be told, not so many years ago, that the abysses of ocean must be void of life for various reasons, amongst which one was that the pressure of the water would be too great for any living thing to endure. Yet many delicate organisms have been dredged up from depths at which the pressure must certainly be no trifle. Now there seems to be just as little difficulty in believing that these organisms existed in a perfect state at the bottom of the ocean, as that shells imbedded in clay would remain unbroken underneath the pressure of a superincumbent ice-sheet of equal or greater weight. If the ice were in motion, the clay with its included shells might be ploughed out bodily, or be merely crumpled and contorted; or it might be ridden over with little or no disturbance; or, on the other hand, it might become involved with subglacial *débris*, and be kneaded up and rolled forward—the shells in this case being broken, crushed, and striated, just as we find that the shells in certain areas of Till have been. The fate of the fossiliferous beds would, in short, be determined by the rate of flow and degree of pressure exerted by the superincumbent quasi-viscous body—the motion of which would be largely controlled by the physical features of the ground across which it crept.

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## V.—Geology of the Channel Islands.

By J. A. Birds, B.A.

### *Part I.—The Older Rocks.*

In the most extended view, the Channel Islands may be regarded as fragments and relics of the Eastern or European coast of the Atlantic, reckoning from the North Cape to Cape St. Vincent, and including the Western shores of Scotland and Ireland, and the promontories of Pembrokeshire and Cornwall. They are excellent illustrations, says Professor Ansted, "of those spurs and tongues of porphyritic rock, of which almost all the promontories of the Atlantic coast of Europe consist."[1] Very small and insignificant specks indeed they seem in such a length of coast, stretching from

[1] The Channel Islands, by Ansted and Latham, 1862, p. 247.

lat. 37° to 72°, or upwards of 2000 miles; but there is a charm in such wide horizons, and it is a very allowable indulgence so to connect the little with the great, and to consider the position of such little specks in relation to the geography of Europe; one might almost as well say, of the world at large. Having refreshed ourselves, however, with such a glance at their widest geographical relations, we must be content to confine our view within a very much narrower compass, and to consider these islands simply as relics of a tract, which once formed part of what is now Normandy and Brittany; just as the Scilly Isles and Lundy Isle are relics of an area which once was connected with Cornwall and Devonshire—the original and actual basis indeed of Arthur's legendary kingdom of Lyonnesse. This itself is no narrow view; but even if it were, still we are not under any necessity—as in geology one never is—of losing a great horizon and burying ourselves in a mass of details; the only difference is that we must change our point of view, and regard the area under consideration in the aspect, not of space, but of time. Viewed in this way the series of rocks become so many visible and tangible links, or landmarks rather—the chain being so broken—leading the mind back into an almost infinite past.

It is not my purpose, of course, in this paper, to attempt anything like a complete account, or even a *resumé*, of the geology of these isles; that may be fully gathered from such articles as Dr. MacCulloch's, and others in the Transactions, Proceedings, and Quarterly Journal of the Geological Society; from Duncan's "History of Guernsey"; and, above all, from Prof. Ansted and Dr. Latham's work on the "Channel Islands." All that I desire to do is, to ask one or two questions about points which seem to me of chief interest and importance, to bring together information from the above works and elsewhere upon these points, and to add to this the result of my own observation during the latter part of last year.

The first question is as to the age of the granites, or rather syenites, 'granitals,' schists, porphyries, sandstones, etc., of which the islands consist.

Besides Prof. Ansted's conjectures that the grits and sandstones of Alderney are probably of Permian or Triassic age,[1] and the older conglomerate of Jersey of the age of the Cherbourg grits[2] (Bunter or Lower Trias), I am not aware of any observations having been published as to the date of the rocks.

Looking at a geological map of the north of France, or of Normandy and Brittany, with which the islands stand in closest connexion, one would conjecture *à priori* that the sedimentary rocks at least were either Silurian or Devonian, more especially when we observe what is probably a continuation of these rocks across the Channel in Devonshire and Cornwall.[3] The only positive evidence in favour of such a supposition, that I have seen, is a small patch or

[1] The Channel Islands, p. 269. [2] Ibid, p. 274.

[3] See an article by the late Mr. Salter on "The Pebble Bed at Buddleigh Salterton," Geol. Mag. 1864, Vol. I. p. 5, etc.

rather one or two bands of schistose strata which make their appearance in Rocquaine Bay, Guernsey ; and, again, the schists or shales of Jersey.

In the former case the rocks are of a bluish-grey colour, weathering brown, and have at first sight a general Silurian or Devonian aspect. They are referred to by Prof. Ansted in a note concerning the absence of any deposits in Guernsey more recent than the fundamental syenites and gneiss : " A small patch of clayslate," he says, " in Rocquaine Bay is hardly an exception."

This so-called patch (where I examined it) consists of two or three bands of slate, which are imbedded in the midst of a felspathic syenite, and dip at a very high angle to the east. I traced them for about fifty or sixty yards on the land side of the fort called Rocquaine Castle till they became lost under the sea. Probably, at low water, they may be found in other parts of the bay. The cavities left by decomposed felspar have often a very deceptive resemblance to casts of Brachiopoda, and to encrinital remains ; but I searched in vain for any trace of fossils. Possibly these may yet be discovered. Should this not be the case, the schists will not, of course, yield any evidence of their age, or of that of the felspathic and hornblendic rocks amid which they lie. In a mineralogical point of view, however, they would still be interesting, as showing a stage in the progress of metamorphism, viz. a passage from sedimentary schists into a greenish-grey porphyritic rock containing crystals of felspar and calcite (?).

Alderney, according to Ansted,[1] besides the portion of sandstone above referred to, consists entirely of syenite, with the exception of a single boss of hornblendic porphyry, upon which Fort Touraille is erected. Ortach and the Casquets, although few, if any, geologists have landed to examine them, are believed to consist of similar syenite or porphyry with cappings of the same sandstone as Alderney. It is said that the syenite enters and pierces the sandstone in the Casquets—a very important point—but one which requires confirmation.

Of Guernsey I can speak from personal observation. It is divisible geologically into two or three very unequal portions by a line drawn N.W. from some quarries just above St. John's Church, in the town of St. Peter, to some other quarries below Capelles School ; and thence again S.W. to a quarry on the right or north side of the Cobo Road, close to Cobo Bay. About three-quarters, or rather four-fifths, of the island south of this line consists of a very felspathic syenite and gneiss, and the remaining quarter or fifth of a hornblendic 'granital'—a compound of quartz and hornblende. A third division consists of a syenite often charged with specks and flakes of mica. This micaceous syenite may be traced along the coast from near the centre of Cobo Bay and Grandes Rocques almost to Fort Doyle, at the north-eastern extremity of the island. In the centre of Grand Havre, however, and on Mont Cuet—between Grand Havre and Lancresse Bay—and perhaps at some other points

[1] The Channel Islands, p. 268.

along the shore, the syenite is interrupted by veins of the hornblendic granital. It does not extend far inland, but is soon replaced by the mass of hornblendic granital constituting the north of the isle.

Of the felspathic portion of Guernsey I have nothing to remark, more than that it furnishes magnificent crystals of felspar, especially in Moulin Huet and Petit Bot Bays, surpassing in size and brilliancy of colour any in the porphyritic granites of Cornwall, or Shap Fell, Cumberland. The cliffs are frequently intersected by veins of greenstone and felstone running both parallel with, and at right angles to the apparent bedding or jointing of the syenite. The hornblendic portion of the island also occasionally (*e.g.* at St. Sampson's) affords splendid crystals of black hornblende, finer indeed than any I have ever seen in England or Scotland. The principal veins in this portion are of felstone, serpentine steatite, and epidote, of which last I found some rather pretty crystals imbedded in quartz. Chlorite frequently occurs in the form of coatings and stains.

The principal axis of elevation of the whole area of the islands is said by Prof. Ansted to run W.N.W. and E.S.E., and is regarded by him as a continuation of the great east and west elevations affecting the Continent of Europe, which are best illustrated in the range of the Alps and Pyrenees.[1]

The little island of Sark consists of syenite, with similar veins, as in Guernsey, of greenstone, felstone, serpentine, steatite, etc., and of hornblendic rocks, along with porphyry and trap. The hornblende is said to occupy the extreme ends, and to form a belt across the centre of the island, while the felspathic syenite fills up the intervals. The axis of elevation here, and also in the little islands of Herm and Jethou, between Sark and Guernsey, is nearly at right angles to the axis of the latter, or N.N.E. and S.S.W., and corresponds, says Ansted, rather with recent elevations and depressions than with the original upheaval.[2]

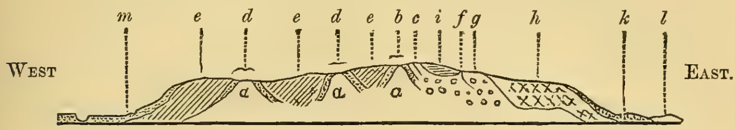
I was not fortunate enough to find any, or at least good specimens of the minerals with which Sark is said to abound. The old mine-heaps appear to have been thoroughly ransacked, and the shores are inaccessible except at a few points; only on the beach at Epercherie —the original landing-place—I picked up specimens of fine black hornblendic porphyry containing well-defined crystals of felspar, and a few pebbles of agate and jasper, generally much decayed, as well as some of serpentine, and a green mineral, which I take to be actinolite. The vein of kaolin, stained purple and pink, crossing the north side of the Coupée, is very conspicuous. Dr. MacCulloch, in his map of the island, indicates three other veins,—1, of quartz, chalcedony, jasper, and agate; 2, talcose schist with steatite; 3, chlorite with pyrites; crossing the Coupée parallel with the kaolin. None of these are visible from above, one side being covered with detritus, and the other plunging down perpendicularly into the sea.

[1] Ansted and Latham's Channel Islands, pp. 256, 260.
[2] Ibid, p. 263.

The shores of Sark are generally more or less inaccessible; and the only way to explore the island properly would be from a boat.

Of Jersey Prof. Ansted has given the following section, which I take the liberty of copying from his and Dr. Latham's work.[1]

GEOLOGICAL SECTION ACROSS JERSEY FROM EAST TO WEST.




Length of section 11 miles.

*a*. Firm syenite. *b*. Rotten syenite. *c*. Quartzite. *d*. Indurated shale. *e*. Shale. *f*. Hornstone schist. *g*. Old conglomerate. *h*. Newer conglomerate. *i*. Sandstone. *k*. Raised beach. *l*. Pebble beach. *m*. Blown sand.

The syenite, indeed, forms the basis of all the other rocks. It does not, however, as might be supposed from the section, protrude at three distinct points, the intermediate spaces being covered with shale, but rather appears as three separate masses, in the north-west, south-west, and south-east of the island. The first and largest of these may be followed continuously along the coast from L'Etac, round by Grosnez and Plemont Points to Point Sorel, and the quarries north of St. John's Church; it is traceable inland by the quarries of Mont Mado, and a little south of the Wesleyan Chapel called Les Frères, to the head of St. Mary's Valley, near the fifth milestone, and thence almost in a direct line to L'Etac. The second mass occupies nearly the whole of the parish of St. Brelade, and forms the coast-line from La Carrière opposite La Rocca Tower, in St. Ouen's Bay, to the Corbières rocks; and thence to a point a little below Noirmont Manor House. The boundary of this mass inland is generally covered on the west by blown sand, but it appears again between Tabor Chapel and St. Aubin's in the shape of a granital of quartz and felspar, very subject to decomposition, in which state it forms a fine china-clay. Quarries have been opened here, and the clay is exported to England. From this point the boundary may be traced S.E. to the shore again under Noirmont Manor. The third and last mass of the syenite forms the S.E. corner of the island, and may be followed along the coast from Fort Regent at St. Helier's to La Rocque Point. It is interrupted at two points, viz. at La Collette under Fort Regent, and in the headland of Samares, by veins of hornblendic granital. Between La Rocque Point and Mont Orgueil Castle the rocks are covered by the sands of Grouville Bay; but the syenite, which here passes into a granital (quartz and felspar), may be traced inland by Gorey Church, and

[1] The Channel Islands, p. 270. Geological maps of the islands there are none, at least I have seen none, except the sketch-maps appended to Dr. MacCulloch's "Account of Guernsey and the other Channel Islands" in the first volume of the Geological Society's Transactions. The Ordnance maps of Guernsey and Jersey are on a scale of six inches to the mile, and somewhat expensive; but very good and cheap pocket maps may be had of Guernsey, of Messrs. Staddon and Grigg, High Street, St. Peter Port; and of Jersey, at any of the stationers there.

along the upper road to Grouville, to the windmill above the village, and thence to the neighbourhood of Sion House (where it is very much decomposed)—and last to the quarry east of Victoria College, and the rocks underneath the College itself. Between these three great masses of syenite there lies upon the west a thick formation of shale or schist ($e$), which extends without interruption from St. Ouen's Bay to the western or lower branch of the Val des Vaux, close to St. Helier's. At this point it is broken by an outburst of volcanic rocks, which have altered it into a claystone porphyry, but it appears again in an unaltered form a little north of Sion House, and between Le Bourg and Petit Catillon, north of Grouville Church. The general character of the rocks is that of a bluish-grey argillaceous schist, with bands of hard grit. Sometimes (as near St. Helier's) it is a brown, sandy, finely-laminated shale. Occasionally I observed it take a cherty character, as, *e.g.*, near St. Aubin's, on the right of the main road to St. Brelade's.

The north-eastern portion of the island is occupied by a formation ($f$ and $g$ of Prof. Ansted's section), variously composed of porphyries, hornstone-schist, altered sandstone, quartzite and quartzose conglomerate, which extends in a wide belt or broken arc from Fremont Point, above Bonnenuit Bay, and L'Etaquerel, in Bouley Bay, southward to within about a mile and a half of St. Helier's; and thence eastward by the Grand Val Mill, in the Val des Vaux, till it appears upon the coast again between Anne Port and St. Catherine's Tower, in St. Catherine's Bay. The points where it may be best examined are the quarries at La Crete Point in the latter bay, in a quarry a little north of Grand Val Mill, on the road from the latter to La Boucterie, in Blanche Pierre Quarry, in the lower or western branch of the Val des Vaux, in Bonnenuit Bay, and in the quarries on the Jardin d'Olivet above Bouley Bay. The quartzite and quartzose conglomerate are extensively quarried all along the cliffs between these two bays.

Resting upon this formation ($f$ and $g$), and occupying the whole of the extreme north-eastern corner of the island, from a little south of St. Catherine's Tower, in St. Catherine's Bay, to between L'Etaquerel and La Tour in Bouley Bay, lies a newer argillaceous breccia or conglomerate ($h$), composed mainly of chloritic slate and ferruginous sandstone, but with blocks of syenite, granital, quartz, and many other kinds of rock scattered throughout the mass. The boundary of the deposit inland may be traced from a little west of Carmel Chapel, on the road between the Jardin d'Olivet and Rozel, and near the lodge of Rozel Manor, and thence to a point about half-way between St. Martin's Church and St. Catherine's Bay, where it may be seen resting upon the altered sandstone ($f$). The finest sections, however, are those of the quarries at Verelut Point. Both there, and all along the coast to Rozel—but particularly in Port Saie—there are ample opportunities for its examination.

On the left of the road descending to Bouley Bay, and also, according to Mr. Ansted, at the back of St. Catherine's Bay, there are two small patches of a still newer formation, consisting of a fine-grained red sandstone with clayey and ferruginous bands. In Bouley Bay this sandstone rests unconformably, and almost horizontally, upon nearly vertical strata of the older sandstone or hornstone (*f*). Prof. Ansted believes this latest sandstone to be "quite modern," and to have been "deposited before" (? *shortly* before), "or during the last great elevation."[1] He does not, however, assign any reasons for his belief.

The age, indeed, of all these rocks is as yet a mystery. Not a trace of fossils has been discovered either in the schist (*e*), or in the sandstone portions of (*f*), or in the later sandstone (*i*); only among the pebbles on the beach at Bouley Bay I found many containing what certainly look like the remains of corals and portions of shells. These have probably been derived from the newer conglomerate (*h*); and if their organic character were determined, it might throw some light on the age of the conglomerate. As yet, however, one cannot even say whether the syenites are older or younger than the schist (*e*), it not being known whether they ever enter and pierce the latter, as in Cornwall the granites do the Devonian and Carboniferous rocks, and are thereby proved to be younger than them. The direction of the principal joints, nearly N. and S., is the same as that of the granites in Cornwall, but, this being due to later causes, proves nothing, of course, as to the age of the original formation of the rocks.

It is easy enough to invent theories as to the age and history of the various formations; and, in the absence of further evidence, this is about all that can be done. Dr. MacCulloch, in 1811, described the schist as grauwacké,[2] *i.e.* of Pre-Carboniferous age, and we may perhaps pretty safely assume that it is of some Lower Silurian period, coeval with the Silurian rocks of Normandy and Brittany. (Llandeilo, Caradoc, or Lower Llandovery).

Of the sandstone, and its accompanying felstone and cherty porphyries, and conglomerate (*f* and *g*), there is almost as little evidence as to age. From their general appearance one might imagine them to be of Old Red Sandstone equally as well as of Permian or Triassic age. Only at one point, just above Le Bourg, did I discover the shale (*e*) and the felstone porphyry (*f*) in contact, and here it seemed to me that the shale actually *overlay* the porphyry. Of course this might have been due to a fault or inversion of the strata. But I can hardly think so in this case. Can the porphyries have been eruptive and pierced into the shale?

From the section it does not appear whether the shale is older or younger than the sandstones and porphyries. Prof. Ansted conjectures, however, from the similarity of dip, that the newer Jersey conglomerate (*h*) and the Alderney sandstone may be of the same age; and, if so, that the older conglomerate (*g*) may perhaps belong to the Cherbourg grits (Bunter or Lower Trias). In this case the underlying porphyries and sandstones (*f*) might be somewhat older, or intermediate between the schist (*e*) and the conglomerate (*g*).

[1] The Channel Islands, p. 275.

[2] Account of the Geology of Guernsey and the other Channel Islands, Geol. Trans. 1st series, vol. i. 1st paper.

This is about all that conjecture at present can arrive at. There would seem indeed to be little hope of determining the question as to the age of the rocks from a study of the island alone, or of all the Channel Islands together by themselves. It can only be by comparison of their geology with that of the neighbouring parts of the Continent—of Normandy and Brittany—that we can expect a solution of the problem.

In addition to the syenites, and the sedimentary and porphyritic rocks above described, there is a very important accumulation of volcanic rocks (trap, porphyry, and amygdaloid), in the immediate neighbourhood of St. Helier's, and which does not seem to have been noticed either by Dr. MacCulloch or Prof. Ansted. Commencing at Gallows Hill, on the west of the town, the series may be traced for about two miles northward, across both branches of the Val des Vaux, to near the Grand Val Mill. It occurs again between the two houses called the Hermitage and Bagatelle, in the quarry east of Victoria College, and at the foot of St. Saviour's Hill. It may be well seen in the quarries at the bottom of Gallows Hill, and on the road up the western branch of the Val des Vaux, where the focus of the eruption seems to have been. There is nothing to indicate the age of these rocks except the alteration of the shale (*e*) in their neighbourhood (as, *e.g.*, on the Trinity Road, and other places) into a claystone porphyry, proving them to be more recent than it. The mention of this altered rock leads to another and final question; namely, what is the cause of metamorphism in the various rocks of Jersey? It is not the syenite: for at, or close to, its junction with the shale (as, *e.g.*, on the ascent by the path from St. Aubin's into the St. Brelade's Road), the latter is quite unaffected.

The volcanic rocks may account for the alteration of the shale (*e*) into claystone-porphyry; but they do not account for the felstone and hornstone-porphyries (*f*), which exhibit the same character, both in the immediate neighbourhood of the trap (*e.g.* in the quarry N. of Grand Val Mill), and miles away from it (*e.g.* at La Crete Point, in Blanche Pierre Quarry and in Bonnenuit Bay). These would seem to be porphyries belonging properly to the sandstone series (*f*), but whether contemporaneous or intrusive I am unable to say. Here again the study of the geology of Normandy and Brittany is essential to the understanding of that of Jersey and the other Channel Islands.

## NOTICES OF MEMOIRS.

On the Metamorphism of the Rocks of the Channel Islands. By Prof. Liveing, etc., etc.

A PAPER was recently communicated to the Cambridge Philosophical Society (Oct. 29th, 1877) by Prof. Liveing, in which the author traced the connexion of the rocks in Guernsey, and pointed out the extreme variations in the amount of change these rocks and some of those in the other islands had undergone, from well stratified gneiss to highly crystalline syenite. He attributed the coarsely crystalline structure of these and other granitic rocks to long-continued variations either of temperature or of the action of some partial decomposition, such as steam or other gases may be supposed to effect, rather than to fusion; and he pointed out that there were granitic veins in the islands which appeared to have originated like ordinary quartz-veins, while others were intrusive, and concluded that the granitic structure was a result of metamorphosis, and that the proof of the igneous origin of a granitic rock must be determined by considerations independent of its crystalline character.

## REPORTS AND PROCEEDINGS.

Geological Society of London.—December 19th, 1877.—Prof. P. Martin Duncan, M.B., F.R.S., President, in the Chair.

The following communications were read:—

1. "On *Argillornis longipennis*, Owen, a large bird of flight, from the Eocene Clay of Sheppey." By Prof. Owen, C.B., F.R.S., F.G.S., etc.

In this paper the author described some remains of a large bird obtained by Mr. W. H. Shrubsole from the London Clay of Sheppey, consisting of parts of fractured humeri belonging to the right and left sides of the same species or perhaps individual, and including the head of the bone, with portions of the upper and lower parts of the shaft. The texture of the shaft, the thinness of its bony wall, and the large size of the cavity recall the characters of the wing-bones of the large Cretaceous Pterodactyles. The author indicated the characters which led him to regard the remains under consideration as those of a volant bird, most nearly approaching the genera *Pelecanus* and *Diomedea*; and as the evidence derived from the cranium of *Dasornis* would indicate a bird too large to be upborne by wings to which these bones might have belonged, whilst the skull of *Odontopteryx* is far too small to have formed part of a bird with wings as large as those of the Albatross, and *Lithornis* and *Pelargornis* are excluded by the characters of their remains, the author concluded that the bones obtained by Mr. Shrubsole furnished indications of a new genus and species of flying birds, for which he proposed the name of *Argillornis longipennis.* He regarded it as probably a longwinged natatorial bird, most nearly related to *Diomedea*, but considerably exceeding the Albatross (*D. exulans*) in size. The author remarked that the generic name *Megalornis*, proposed by Prof. Seeley for the *Lithornis emuianus*, Bowerb., had been preoccupied by the late Mr. G. R. Gray.

2. "Contributions to the History of the Deer of the European Miocene and Pliocene Strata." By Prof. W. Boyd Dawkins, M.A., F.R.S., F.G.S.

The author commenced by referring to the difficulties attending the study of the European Miocene and Pliocene Deer, and indicated that the majority of the known antlers may be referred to two categories—an earlier or Capreoline, and a later or Axidine type. To the Capreoli he referred the following species:—*Dicroceros elegans* Lart. (=*Prox furcatus*, Hemel), *Cervus dicranoceros*, Kaup (including *C. anoceros* and *trigonoceros*, Kaup), and *Cervus Matheronis*, Gerv. (=*C. Bravardi*), from the Miocene, and *Cervus australis*, Gerv., and *C. cusanus*, Croizet & Jobert, from the Pliocene. To the Axeides belong *Cervus Perrieri*, Cr. & Job. (including *C. issiodorensis* and *pardinensis*, of the same authors), *C. etneriarum*, Cr. & Job. (=*C. rusoides*, Pom., and *C. perollensis* and *stylodus*, Brav.), *C. suttonensis*, sp. n., and *C. cylindroceros*, Brav. (including *C. gracilis*, Brav.), all from Pliocene deposits. Besides these, the author noticed a species *incertæ sedis* under the name of *Cervus tetraceros*, Dawkins, which he regards as coming nearest to the Virginian Deer, or Cariacou (*Cariacus virginianus*). From the examination of the antlers of these species he indicates that in the Middle Miocene age the cervine antler consisted of a simply forked crown, whilst in the Upper Miocene it becomes more complex, although still small and erect, like that of the Roe Deer. In the Pliocene it becomes larger and more complex, some forms, such as the *Cervus dicranios*, Nesti, being the most complicated of known antlers. The successive changes are analogous to those observed in the development of the antlers of the living Deer with increase of age. In the Miocene we have the zero of antler-development, and the Capreoline type is older than any other. The nearest living analogue of the Miocene Deer is, according to the author, the Muntjak (*Styloceros*), now found only in the oriental region of Asia, along with the Tapir, which also coexisted with *Cervus dicranoceros* in the Miocene forests of Germany. The Pliocene Deer, again, are generally most nearly allied to the oriental Axis and Rusa Deer, the only exception being *Cervus cusanus*, the antlers of which resemble those of the Roe, an animal widely spread over Europe, and Northern and Central Asia. The alliance of these Pliocene Deer with those now living in the Indian region is regarded by the author as a further proof of the warm climate of Europe in Miocene times, confirmatory of the conclusions arrived at by Saporta from the study of the vegetation.

3. "On the Occurrence of *Branchipus* (or *Chirocephalus*) in a fossil state, associated with *Archæoniscus*, and with numerous Insect-remains in the Eocene Freshwater Limestone of Gurnet Bay, Isle of Wight." By Henry Woodward, Esq., F.R.S., F.G.S.

The remains of Crustacea and Insects noticed in this paper were obtained by Mr. E. J. A'Court Smith from a thin bed of limestone belonging to the Osborne or St. Helen's series at Thorness and Gurnet Bay in the Isle of Wight. The collection is the result of about twenty years' work. The insect-remains comprise about fifty specimens of Diptera, including wings of Tipulidæ and Culicidæ, and the pupa apparently of a Gnat, one wing of a Hemipterous insect, and a flattened Homopterous insect identified by Mr. F. Smith with *Triecphora sanguinolenta*; two specimens referred to the Lepidopterous genus *Lithosia*; only three Orthoptera, one a *Gryllotalpa*, the other two belonging to a Grasshopper; thirty-five Hymenopterous wings, thirty-three of which are referred to Ants of the genera *Myrmica, Formica,* and *Camponotus*; twenty-three examples of Neuroptera referred to *Termes, Perla, Libellula, Agrion, Phryganea,* and *Hemerobius*; and twelve of Coleoptera, including species of *Hydrophilus, Dytiscus, Curculio, Anobium, Dorcus,* and *Staphylinus.* There were also two Spiders. Several species of bivalved Entomostraca have also been obtained from these deposits, and identified by Prof. Rupert Jones. Of the Branchipod Crustacean both sexes are fossilized and beautifully preserved, the males showing their large clasping antennæ, and the females their egg-pouches, with large and very distinct disk-like bodies representing the compressed eggs. Dr. F. Goldenberg notices a fossil from the Coal-measures of Saarbrück which he regards as a Branchipod, and describes and figures under the name of *Branchipusites* (rectè *Branchipodites*) *anthracinus;* but this interpretation of it is at least doubtful. The author names his species *Branchipodites vectensis.* The Isopods accompanying this species are referred to the genus *Archœoniscus,* M.-Edw., and one of them is identified with the *Palœoniscus Brongniarti* of Milne-Edwards. The other is probably a new species, perhaps nearly allied to the existing *Sphœroma serratum.*

4. "The Chronological Value of the Pleistocene Deposits of Devon." By W. A. E. Ussher, Esq., F.G.S., of H.M. Geological Survey.

In this paper the author endeavoured to work out the sequence of events indicated by the Pleistocene deposits of Devonshire. He believed that during late Tertiary times subsidence extended to the south-western counties, and to this he ascribed with some doubt the accumulation of a patch of gravel on the north summit of the Black Downs and of part of the old bone-breccia of Kent's Cavern. In the Glacial period, with the increase of cold, snow accumulated on the high lands, with formation of glaciers, which descended and united to form a great ice-field, planing the surface of a district composed chiefly of Cretaceous and probably Tertiary strata. To this period the author ascribed the formation of the clay with unworn fragments of flint and chert, and doubtfully part of the clays of the Bovey Valley, the clay of Petrockstow, and part of the bone-breccia and the crystalline stalagmite of Kent's Cavern. The Postglacial phenomena he referred to three subperiods, in the first of which, during a gradual amelioration of the climate and disappearance of the ice, large quantities of surface-water were set free, redistributing and removing Tertiary outliers, partially destroying the old ice-beds, and moraine rubbish, and sweeping Secondary deposits from Palæozoic districts. The deposits then formed were supposed to be the old gravel patches of Colford and Orleigh Court, the waterworn materials on the Blackdowns and Haldon, the sands flanking the Bovey Valley, and, with doubt, the redistributed Triassic pebble-beds of Straightway Hill, and part of the cave-earth of Kent's Cavern. The next subperiod he regarded as one of great fluviatile action, the land being higher than at present, though sinking, and the meteorological conditions such as to greatly increase the volume of the rivers. The subsidence having continued to the level of the present raised beaches, reelevation took place, producing greater cold and more extreme seasons, and culminating in the production of continental conditions, permitting the southward migration of a temperate fauna, and the advent of one requiring greater cold. During this period the gravels connected with the formation of the present valley system, the raised beaches, and the "Head" were produced, and, doubtfully, part of the cave-earth and the granular stalagmite of Kent's Cavern, and the clay of Petrockstow and Roundswell. In the last subperiod the author considered that a subsidence took place during which most of the valleys were excavated to their present depth, and forest growth took place upon the old marine plain; the forests were then gradually circumscribed by the encroaching sea and diminishing rainfall, which also led to changes in the streams, and finally the sea entombed the forests and swamps on the coasts, and produced the present cliff-line. The results of this period are the submarine forests, most of the river-valley gravels, and alluvial tracts bordering the present river-courses.

## CORRESPONDENCE.

### THE CORAL RAG OF UPWARE.

Sir,—In the October Number of the Geological Magazine Professor Bonney points out certain facts observed originally by Mr. Henry Keeping—but subsequently confirmed by himself—which are, he considers, incompatible with "the *presumed* section" near Upware given in our paper "On the Corallian Rocks of England," Quart. Journ. Geol. Soc., vol. xxxiii. p. 315.

Our object in attempting the section referred to was to show how the palæontologically higher beds of the south pit could overlie those of the north pit—though they dip towards them; and that they may do so, unless we call in the aid of a fault, the existence of a synclinal is the most natural supposition. Beyond this, the stratigraphy was irrelevant to our paper—and we readily admit that the unconformity between the Corallian rocks and the newer strata might have been more clearly shown. We would merely remark that Mr. Keeping's section, being at right angles to ours, can throw no light on its correctness.

The true reading of the sequence of the Corallian rocks—which, as indicated in column ix. of our table of comparative sections, is not seen—rests entirely on palæontological evidence, and this, though he admits that we may be right "in assigning to the rock of the northern pit a lower horizon than that of the southern," Professor Bonney considers not to be strong. Here then is the only point really at issue between us. We can only say that the two urchins which by their abundance characterize the northern pit, are "species usually indicative of a low position" (see our memoir, p. 367), and their occurrence on or above the horizon of a Rag fauna would be another of those surprises with which we will admit the Corallian series abounds.

The second portion of Prof. Bonney's paper relates to another matter; and here let us at once express our regret that any phraseology of ours should even seem to imply that the Coral Rag of Upware had been "imperfectly" treated in his "Geology of Cambridgeshire." Having said this, we will proceed to discuss the substance of his complaint. The chief points in which our account differs from that of Prof. Bonney are the assignment of the Upware rock of the south pit to the Coral Rag in a restricted instead of a general sense; and the separation of the north pit rock as belonging, not to a mere variation of development, but to a different horizon. That Prof. Bonney called the Upware rock "true Coral Rag, as the word was then understood," was clearly acknowledged in the sentence following the one he quotes, viz. "It has always been called Coral Rag, except by Mr. Seeley." But Prof. Bonney went further. He attempted to show to *what part* of the "Coral Rag as then understood" the Upware rock belongs. He assigned it to the lower part, and therefore to an horizon *beneath* our restricted "Coral Rag";[1] and it is on this point that we differ from him. He did this on account of its containing *Cidaris florigemma*, which he says extends down to the Lower Calcareous Grit. We ask, where? Not, we venture to say, in England.

To prove a negative is of course a difficult task, and the experience of years may be upset by the discovery of a moment. But the fact is that *Cidaris florigemma* hardly ever occurs even in the Coralline Oolite, which in nearly every locality where a sequence can be traced is interposed between the Coral Rag and Lower Calcareous Grit. So far, then, from making the position of this urchin less constant than it was supposed to be, as is alleged by Prof. Bonney in the second paragraph of his letter, our intentions were certainly in a contrary direction, only we find it constant in the *upper* and not in the lower part of the series; or, to speak more accurately, it is most plentiful in the lower portion of the upper division, *i.e.* the restricted Coral Rag. If, however, English geologists are content to derive their impressions of the distribution of the Mesozoic strata of their own island from the detailed accounts of their supposed foreign equivalents by continental authors, we can never get any real data for comparison. In the present instance it would appear that the *Cidaris florigemma* was contemporary with the earlier part of the Coral growths in Eastern France. In the Boulonnais it was pretty uniformly distributed throughout, as M. Rigaux informs us, and he therefore wonders that we consider its position so constant. In England again, except in the Weymouth area, which shows more intermediate conditions, it is almost entirely confined to the uppermost Coral growths. The lower reefs at Highworth and Hackness, though presumably formed under similar physical conditions, are

[1] It may be necessary here to remind the readers of the Geol. Mag. that the Corallian of England admits of four primary subdivisions, as follows in descending order: 1. Supracoralline, or equivalents of the Upper Calcareous Grit; 2. Coral Rag, or zone of *Cidaris florigemma*; 3. Coralline Oolite, or zone of *Am. plicatilis*; 4. Lower Calcareous Grit, or zone of *Am. perarmatus*.

without it. Whether we are to consider that Coral growth began earlier in England than in France, or that *Cidaris florigemma* reached us later, is an interesting question; but this much is certain, that the Coral growths continued to a much later period in Eastern France; hence the idea that *Cidaris florigemma* is indicative of a low Corallian horizon. In the discussion on our paper, Professor Morris pointed out that "the so-called Corallian occupied different zones in different localities on the Continent, stretching, in fact, from the Oxfordian to the Portlandian inclusive." Correlation, to be of any value, therefore, is only to be effected by a detailed examination of both the English and continental areas, without confounding together either the beds of different districts, or those of the same district, as is generally done in all works dealing with the subject.

LONDON, *Dec.* 6, 1877. BLAKE AND HUDLESTON.

P.S. The great stretch of country passed under review in the "Corallian Rocks of England" obliged us to condense lists of fossils as much as possible. Had we given a full list of fossils from the North Pit, it is difficult to see that any doubt as to its age could exist. The following, omitting certain indefinite forms, is as full a list as we have been able to put together:

| | |
|---|---|
| *Ammonites perarmatus* | *Isocardia* (cast) |
| ,, *plicatilis* | *Pygaster umbrella* |
| *Littorina muricata* (var.) | *Echinobrissus scutatus* |
| *Pleurotomaria* (cast) | *Holectypus depressus* |
| *Gervillia aviculoides* | *Collyrites bicordatus* |
| *Opis Phillipsi* | |

Only three of these occur in the South Pit. B. & H.

## CYCADACEOUS PLANTS OF THE DAMUDAS.

SIR,—I beg you will allow me space to correct some erroneous impressions that might be made by certain not sufficiently explained statements published by me in the GEOLOGICAL MAGAZINE, and elsewhere, and to apologize to the gentlemen whom I thereby have had the misfortune to offend. I beg to state that any such effect was as far from my intention as it certainly would be contrary to my interests, and I regret that, when stating facts, I did not more fully notice circumstances that would only be known to those immediately concerned.

The following instances will sufficiently explain this unfortunate misunderstanding.

When writing in the GEOLOGICAL MAGAZINE in November, 1876, p. 489, on the occurrence of Cycadeaceous plants in the Damudas, saying in footnote No. 10 "that they were known long ago," I ought to have explained that the two species (out of three) I mentioned, *i.e. Nöggerathia*, near *Vogesiaca* and *Glossozamites*, although collected some years since, have not before been determined as such, and only *Nöggerathia ? Hislopi* was by its describer (Sir Ch. Bunbury) considered as doubtfully Cycadeaceous, and I see now that my footnote, No. 10, should have been written thus: "that Cycadeaceous plants were collected—but not described," for which I beg to apologize to Mr. W. T. Blanford.

Mr. W. T. Blanford's remark "that Cycads have not hitherto been found in the Damudas" was therefore in so far correct as the mentioned specimens, with the exception of *Nöggerathia? Hislopi*, although found have hitherto not been determined until I did so.

I should also, when writing in the September Number of the Geol. Mag. 1877, p. 431, that "*Zamia Burdwanensis*, McClell., has been described as long ago as 1850," have added that the affinities of this species had been later disputed for many years, Dr. Oldham supposing, from the material at his disposal, that a *Schizoneura* has been mistaken for a *Zamia*, until, through the recovery of the original specimen, this species was proved to be indeed a *Zamia*. (I described this species fully, with its history, in Rec. Geol. Surv. of India, 1877, vol. x. No. 2.)

I wrote in the November Number of the Geol. Mag. 1876, already referred to: "From the occurrence of the genus *Glossopteris* in these beds (Damudas), they have been for a long time brought into connexion with the Australian Coal-measures, and declared without any proof as probably Palæozoic," and I referred to Dr. Oldham, Mr. H. T. Blanford, and Mr. W. T. Blanford as authorities. This was the impression left upon me after the perusal of the papers referred to—but I should have explained that besides *Glossopteris*, some other fossil plants also were mentioned as correlating fossils. I express my regret for having left these other correlations unconsidered, but I hope to be able to explain this point further in the Flora of the Lower Gondwanas in India. This note refers to all my publications on this subject. Ottokar Feistmantel.

Calcutta, *Oct.* 9, 1877.

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## PROFESSOR MILNE AND THE GLACIAL PHENOMENA OF SCANDINAVIA.

Sir,—It is not without great astonishment that I—and, I think, most geologists who have devoted any attention to the post-Tertiary formations of Northern Europe—have read a paper by Professor John Milne in your last July Number.[1] By some observations made from the railway waggon, or the steamer, when travelling through Sweden and Finland, he thinks himself enabled to refute the views since many years universally held by Scandinavian geologists respecting the surface geology of the country. The features usually attributed to the action of glaciers on a continental ice-sheet—as, for instance, the polished and scratched rocks and the boulders—he thinks better explained by the action of coast-ice. If Professor Milne had stayed a day in Sweden, and made an excursion with a Swedish geologist, I hardly doubt that the first part of his Travelling Notes would have been unwritten, for it seems impossible that a person with such good reasoning powers should hold the views advocated in those notes, after seeing a few of these scratched rocks

[1] J. Milne: Across Europe and Asia. Travelling Notes. Part I. London to St. Petersburg. Geol. Mag. Dec. II. Vol. IV. p. 289 *seq.*

and the associated phenomena near enough, and having their bearings pointed out to himself by an experienced guide. As they have now been written, and published in a Journal of such a standing as the GEOLOGICAL MAGAZINE, they ought not to be altogether unanswered, though I think that most of your readers do not need to have the failings of such reasonings pointed out.

The chief argument of Professor Milne against the glaciation theory seems to be that that theory requires great climatal changes, the explanation of which would involve insuperable difficulties. I admit that Science has not yet given a final explanation of these changes, but they are a well-established *fact*, and a fact must be accepted, whether we can explain it or not. As for myself, I think that the physical features—such as the nature of the Till and the striation of the rocks—are in themselves sufficient proofs of a former glacial climate, but there are, besides, ample palæontological evidences. Some thirty years ago, Professor Lovén found that certain shell-banks in Southern Sweden contain a completely Arctic fauna, and the labours of the Geological Survey of Sweden have shown that the stratified clay reposing on the gravel-beds is everywhere characterized by the well-known shell *Yoldia arctica*, Gray, which occurs living only in the most Arctic regions, as the coasts of Spitzbergen and those of *northern* Greenland. Still more striking proofs of a former glacial climate have been, in later years, adduced by Dr. Nathorst, who has, from débris in the lacustrine deposits, found that a vegetation identical with that now prevailing in Spitzbergen (*Dryas octopetala*, *Salix polaris*, etc.) once lived not only in the lowlands of Southern Sweden but also in Denmark. This being the case, it cannot be doubted that a climate cold enough to produce a continental ice-sheet once prevailed so far south as in Southern Sweden.

That, actually, Till is formed, and rocks polished and striated by glacier-ice, is so well known from observations in the Alps and elsewhere, that I think Professor Milne himself cannot deny its capability of producing such effects. He points, however, to one circumstance, often observed in connexion with these phenomena, which he thinks not accountable for by the action of glacier-ice, viz. the occurrence of erratic blocks raised to positions above the rock from which they were derived. He explains their occurrence by the "action of coast-ice upon a rising area." If there should be any meaning in this, Professor Milne ought to have called for a sinking area instead of a rising, as, of course, the question must be of the *relative* height. If a block is attached to floating-ice, and the land is rapidly sinking, the block may be deposited in a relatively higher position than that of the parent rock, but not if the land is rising. There are, however, many instances of blocks derived from lower positions, in places where the water never reached. Thus, in Westrogothia blocks of the Cambrian Sandstones are often found reposing on the summits of the Silurian mountains, several hundred feet above their parent rocks, on heights which the sea never reached in post-Tertiary times; and many similar and still more striking instances are recorded from other countries by

Törnebohm, James Geikie, and other observers. In such cases it is quite impossible to admit floating-ice as the working cause, and we must recur to glacier-ice. It is not here the place to discuss the physical conditions which produce these effects; it is enough to point to the *fact.*

If it is thus evident that the phenomena in question *can* have been effected by the action of a continental ice-sheet, it remains for us to show that they *cannot* have been effected in the manner advocated by Professor Milne.

That the Till—which in no part of Sweden is more developed than in the south—cannot have been formed by the action of floating-ice, is evident to any one who has seen some sections of that deposit, with its striated blocks, heaped confusedly together in the tough tenacious mud. We have, in Sweden, in many places, gravel-beds which have evidently been deposited by shore action, but they have quite another aspect; the gravel is more or less stratified, the stones are rounded, not scratched, and the fine mud is washed off, so that this gravel is far less coherent than the Till. The scratches in the rocks are usually best marked below the Till, and it is therefore probable that the result is from the same cause. That they cannot result from the action of coast-ice is evident from many reasons. Firstly, it is impossible to conceive how the scratches could have such a constant direction in large regions, if they were produced by coast-ice. Professor Milne himself correctly remarks, that the directions of the scratches "point seawards, or else to the lowest land," but, strangely enough, he adds that this circumstance is rather more favourable for his own views. Everybody, however, knows that glacier-ice moves downwards, and therefore it is natural that the scratches, on the whole, have that direction, if produced by glacier-ice. On the contrary, if produced by coast-ice, their direction is independent of the slope of the land, and must vary according to the currents and the winds. Further, in the isles along the Baltic coasts of Sweden, the striation and polishing is most marked on their landward face, from whence the glacier must have come, whereas their outer sides ought to have been more polished and scratched, if the coast-ice had produced these effects.

It cannot be denied that, as Professor Milne says, the abrading action of coast-ice is an undoubted fact, but it must be remarked, that in the coasts of Sweden and Finland, and especially near the route followed by him, this action is excessively small. The rocks are there so hard and compact, and the force of the waves so small, that their action on the rock-surface is hardly perceptible. A rock may be exposed there for hundreds of years to the waves, without the finest scratches being abraded. Professor Milne thinks that, to be preserved, they "must always have remained above sea-level, or else have been shielded by some protective covering during both subsidence and elevation," but it is so far from this being the case that, on the contrary, the scratches are much better preserved beneath the water than in the open air a few feet above it. In the open air the scratches usually become obliterated in a few years by the action of the atmospheric agents, and, above all, by the lichens. This is also the reason why the smaller islands and the lower portions of the larger ones, as Professor Milne remarks, are of a whitish colour. As long as the waves hinder the lichens from attaching themselves to the rock, it preserves its scratched and polished surface, but when elevated a few feet above the sea-level, it soon becomes rough and dark. In places that were sheltered from the action of the glacier-ice, the rock is never polished and scratched, though on our coasts these places are usually the most exposed to the action of the waves and to coast-ice.

GEOLOGICAL SURVEY OFFICE, STOCKHOLM, *November* 30*th*. — G. LINNARSSON.

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## DEVONIAN GEOLOGY.

SIR,—One is scarcely surprised to find that the papers of Messrs. H. B. Woodward and C. Reade, in the last October Number of the GEOLOGICAL MAGAZINE, afford such strong support to the masterly interpretation of the Geology of Devonshire given to the Geological Society by the late Professor Jukes and published at his own expense.

Professor Jukes's knowledge of the Irish rocks with which he classed those of Devonshire, together with his powerful and practised ability for field observation, entitled his opinions to more consideration than at the time they appeared to receive.

Now that he is gone, it is gratifying to see his 'able outline' being ably filled in with careful details, and should the further revision still bear out his views, this will show how apt was a remark he often made regarding puzzles in field geology, "Put all the evidence down, and it will explain itself."

WIJJIYAN, *Nov.* 19*th*, 1877. — BENWYAN.

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## THE VOLCANIC ROCKS OF SHROPSHIRE.

SIR,—Mr. S. Allport, in his valuable paper "On Certain Ancient Devitrified Pitchstones and Perlites from the Lower Silurian District of Shropshire" (Quart. Journ. Geol. Soc., vol. xxxiii. part 3, August, 1877, p. 449), read May 23rd, 1877, announced the discovery of the bedded character of the so-called "Greenstone" of the Wrekin. The same fact was communicated by me to the Society on March 21st, 1877, in my paper "On a new area of Upper Cambrian Rocks in South Shropshire," which however did not appear until the publication of part 4 of the Quart. Journ. Geol. Soc., in November, 1877, p. 652. The value of this discovery will be seen when it is remembered that these "Lower Silurian" rocks are really Cambrian, some of them clearly as ancient as the Lingula Flags, if not Menevian, and that *they rest upon the bedded volcanic series unconformably.* I am working out the details of this great formation, but shall not publish until I have collected further materials.

CHARLES CALLAWAY.

WELLINGTON, SALOP, *Dec.* 11*th*, 1877.

THE

# GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. V.

**No. III.—MARCH, 1878.**

## ORIGINAL ARTICLES.

### I.—On a Collection of Pleistocene Mammals Dredged off the Eastern Coast.

By William Davies, F. G. S.;
of the British Museum.

Of the many private collections of vertebrate fossils found on or off the coast of the Eastern counties, none surpass in palæontological and also in geological interest the fine collection made with much zeal and care by Mr. J. J. Owles, of Yarmouth, inasmuch as the larger portion of the specimens are exclusively the remains of Postglacial Mammals, and were brought up in the fishermen's dredge, either from, or in close proximity to the well-known Dogger Bank, thus proving conclusively the existence of submerged Pleistocene or Postglacial land lying off the Eastern coast in the North Sea. Prof. Boyd Dawkins is the only author, as far as I am at present aware, who has made any reference to this really valuable series of remains, and then only incidentally in his memoir, "On the Distribution of Postglacial Mammals."[1]

The collection having been deposited in the British Museum, where of necessity it will be absorbed and distributed in the general collection, and its unity be lost; is worthy of being placed upon record as a whole, on account of the interest it possesses in relation to the geological history of the bed of the sea lying off the Norfolk coast. The species represented in it are—

*Ursus*, sp.
*Canis lupus*, Linn.
*Hyæna spelæa*, Goldf.
*Cervus megaceros*, Hart.
*C. tarandus*, Linn.
*C. elaphus*, Linn.
*Cervus*, sp.
*Bos primigenius*, Boj.
*Bison priscus*, Boj.
*Equus caballus*, Linn.
*Rhinoceros tichorhinus*, Cuv.
*Elephas primigenius*, Blum.
*Castor fiber*, Linn.
*Trichechus rosmarus*, Linn.

and some large vertebræ of Cetaceans of a later date. The collection contains altogether about 300 specimens. Of these the remains of the Mammoth are most numerous, exceeding one hundred specimens, and consisting of portions of jaws, detached molars, tusks, bones of the trunk and limbs. Of separate teeth and jaws there are upwards of seventy, representing nearly as many individual Mammoths; of tusks there are four, one of large size, but imperfect; three quite perfect, but of comparatively young animals, each of which shows

[1] Quart. Journ. Geol. Soc. vol. xxv. p. 192.

the characteristic spiral curve. Of the first or milk series of teeth there are but few in the collection; the larger portion of the true molars are of aged adults, for the ultimate molar alone is represented by twenty-four specimens, many of large size, and some much worn. They nearly all exhibit the typical characters and structure of the teeth of the Siberian Mammoth; the enamelled plates being thin, numerous and closely set.

The Tichorhine Rhinoceros is represented by a fine skull nearly perfect, and containing a series of five molars on the right side, and the fourth premolar on the left; the cranial portion of another skull, detached teeth and bones. The skull is interesting as showing an extensive fracture of its facial portion, just in front of the interorbital platform, and just clearing the anterior orbital rim. The fracture had subsequently healed, but had left a large scar on the bone, causing a deflection of some three or four degrees from the median line of the cranium. This deflexion also extends, but in a greater degree, to the palate and premaxillæ; it has also affected the nasal septum, which has been forced on one side and its symmetry destroyed, being convex on one side, and concave on the other. The animal appears to have lived long after receiving this fearful injury, probably derived in an encounter with one of its own kind, or with one of the huge Mammoths its contemporaries.

The remains of the Reindeer (*Cervus tarandus*), consist of a cranium, wanting the facial portion, a ramus of a mandible and portions of antlers, one a beam more than four feet in length. The species above noticed only occur in deposits of Postglacial age, the other species given in the list above as having been found with them are common both in Pre- and Postglacial formations.

The remains of the Carnivora, usually rare in river or other aqueous deposits, are few in number, consisting only of the ramus of a mandible of the Hyæna, a skull and cervical vertebræ of the Wolf, and a femur of the Bear, the species undetermined. The Cervidæ are represented by crania of two males and a female of the great Irish Deer (*Cervus megaceros*); crania of the Red Deer (*C. elaphus*), and also several vertebræ and portions of antlers of species not determined. The Bovidæ are represented by horn-cores, teeth, vertebræ and limb-bones, and the Horse by the occipital portions of two skulls, and bones of the trunk and limbs.

The finely-preserved mandible of the Walrus, with the exception that the coronoids are wanting, and that the teeth have fallen from their sockets, is in every other respect perfect. Its age may be a moot point; nevertheless, from its state of fossilization and external colouring, which are the same as many of the undoubted fossil bones and tusks with which it was found associated, I am led to claim for the Walrus a place in our lists of British Pleistocene Mammals, where it has hitherto not been admitted, though Mr. Thomas Southwell, in an interesting paper upon this animal in "Science Gossip," for January, 1877, p. 3, states that "the skull has been found in the peat near Ely." If this find can be authenticated, it has as good a claim to be regarded as a British fossil as the Grampus skull discovered in the Fens of Lincolnshire and described by Prof. Owen in his "British Fossil Mammals." Its fossil remains are also said to be found in France; and in the Crag, enormous incisors of probably a closely allied animal (*Trichechodon*, Lank.) are far from uncommon. Like the Lemming and other land animals, the Walrus may have migrated from our shores when the climate and waters were no longer congenial to its existence.

The skull of the Beaver, though undoubtedly fossil, may have been a later introduction; and the bones of the larger Cetacea I regard as semi-fossil bones of Post-Tertiary age.

It is Mr. Owles' impression that any large collection of similar fossils will never be made again from the area in which his collection was obtained. The Dogger Bank for many years, he states, has been so scraped and sifted by the fishermen's dredge, that a tooth or a bone is now seldom brought to the surface on it.

From Preglacial deposits there are a few teeth of *Elephas antiquus* and *Elephas meridionalis*, of this species there is a fine entire germ of an ultimate lower molar.

In the collection, and obtained from the same sea area, I discovered the centrum of an anterior caudal vertebra of an Iguanodon, which must have come from a much older deposit. Externally it is indistinguishable from the other bones, having the same deep brown colour, and its surface is covered with the shells of small *Balani*, tubes of *Serpulæ*, and cells of Polyzoa, but its mineral condition is very different, petrefaction being complete, all its cellular tissue being permeated by foliated sulphate of lime, resembling in this respect many Dinosaurian bones from the Wealden of the Isle of Wight; and thus giving it a Wealden rather than a Lower Greensand facies. But whatever the deposit from which it was obtained, it has not been transported from a distance, for it has been subject to no water-wearing action; the epyphysial rugosities at either end are very slightly worn, and the natural margins are intact, as is also the chevron bone depression; the walls of the neural arch are present, but the top with the process is absent. The fractured surfaces of the neural walls show the splintery fracture of a recent bone, with the points very slightly abraded, as if the spine had been broken off before fossilization had commenced. This interesting fragment is a geological puzzle; that it was originally deposited where it was discovered is proved by its angularity, and there is no doubt as to its species, which is also limited to the Wealden and the Lower Greensand. Its mineralization points to the former as the bed from which it was probably derived, yet there is no present evidence that the formation extends to the Norfolk coast. The officers of the Geological Survey employed upon that district may possibly solve the difficulty.

Of the Norfolk coast fossils, the British Museum acquired in 1842 and 1843 the collections made by the Rev. C. Green from the Forest-bed in the neighbourhood of Bacton, Ostend, etc., and briefly described by him;[1] and subsequently, in 1858, the large and well-

[1] The History, Antiquities and Geology of Bacton (Norwich, 1842).

known series of Elephant and other vertebrate remains obtained by the Rev. J. Layton, from the eastern coast cliffs, and from the beach and the celebrated oyster bank lying off Happisburgh. Most of the objects in this collection are also referable to the Forest-bed period.

The celebrated Norfolk coast "Forest-bed" collection, made by the Rev. John Gunn, F.G.S., now forms a part of the Norwich Museum, where the geological collection of the late Mr. Samuel Woodward is also preserved.

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## II.—Notes on some Fossil Bivalved Entomostraca.

By Prof. T. Rupert Jones, F.R.S., F.G.S.

(PLATE III.)

*Introduction.*—Notes and references accumulating for some years have induced me to offer some remarks on a new fossil *Estheria*, and on some already known, of Carboniferous, of Permian, and of Triassic age; also a description of some fossil Ostracoda from the Ironstone of Shotover, near Oxford, involving remarks on all the known Wealden species; and lastly notes on some species found in the Purbeck strata of the Subwealden Boring, near Battle, in Sussex.

The specimens shown in Plate III. are illustrated under favour of a Grant from the Royal Society for the purpose of figuring the fossil Bivalved Entomostraca.

### I. *An* Estheria *from the Karoo Formation, near Cradock, Cape Colony, South Africa.*

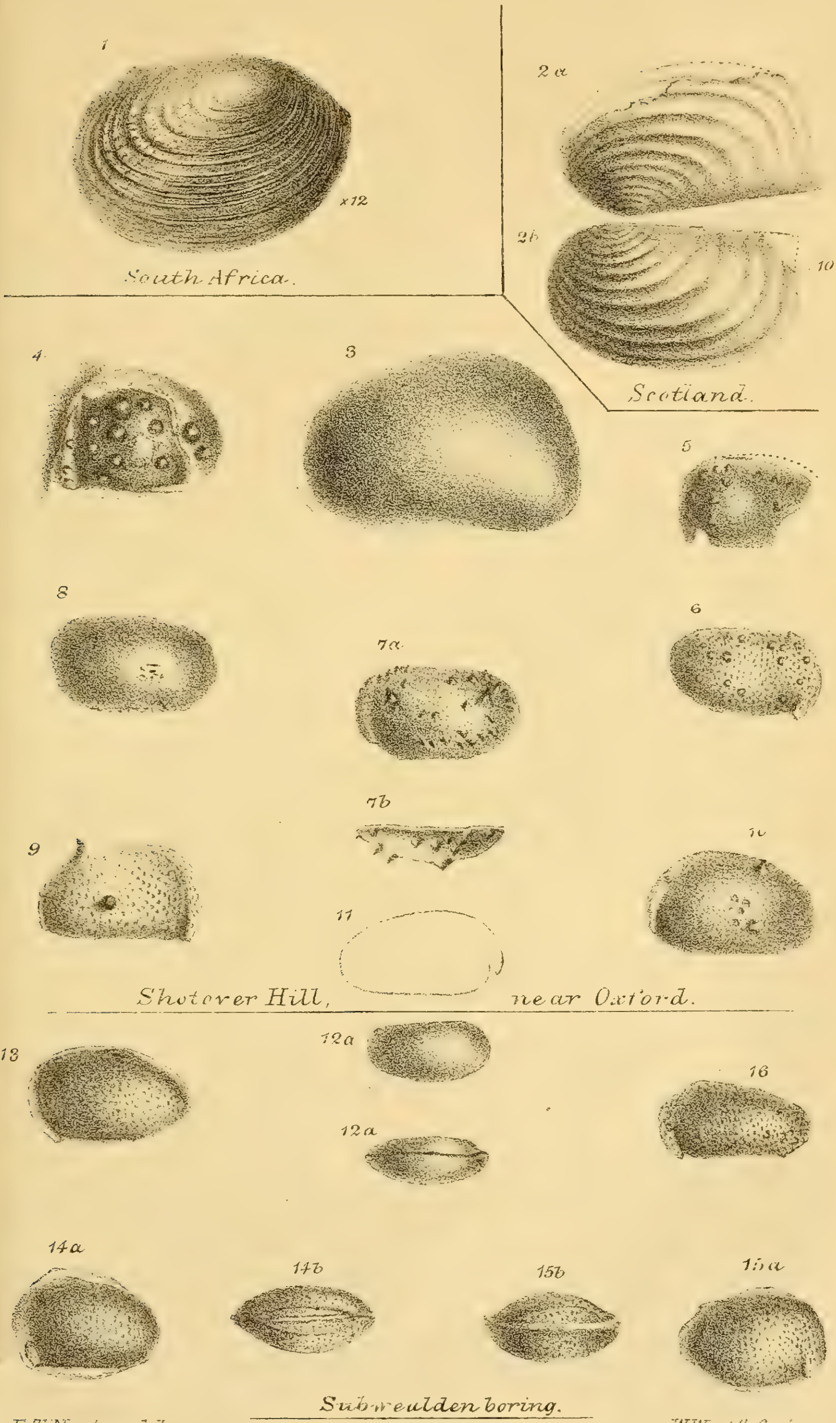
Estheria Greyii, sp. nov. Plate III. Fig. 1.

Valves almost elliptical, except that the dorsal is less convex than the ventral edge, and the dorsal angles are strongly pronounced. The antero-dorsal angle points forward, and is rather low down. The umbo is just within the anterior third of the valve. Of the numerous concentric ridges, those nearest the ventral margin are small and close-set; about twelve larger ridges, wide-apart, mark the middle and more convex surface of the valves. No sculptured or pitted ornamentation is observable. Radiating wrinkles of the shell, under pressure, as shown in the drawing, are not uncommon. Length $\frac{1}{6}$ inch; height $\frac{1}{10}$ inch. Fig. 1 shows a right valve; magnified twelve diameters.

Numerous more or less flattened valves occur on the bed-planes of a hard dark-grey shale, from the *Karoo Formation* near Cradock, in South Africa. The specimens were found by the late Dr. George Grey, when "excavating the shales to examine if they would yield roofing material"; see Quart. Journ. Geol. Soc. vol. xxvii. (1871), pp. 49 and 50. Specimens are in the Geological Society's Museum and my own Collection.

These little fossils[1] are interesting as giving some support to the

[1] *Estheria* and its congener the *Limnadia* received much elucidation at the hands of Prof. E. Grube, of Breslau, in his memoir "Ueber die Gattungen Estheria und Limnadia," etc., in the Archiv für Naturgeschichte, Jahrgang xxxi. 1865.




E. T. Newton del. G. Sharman lith. W. West & Co. imp.

Fossil Entomostraca.

late Mr. A. G. Bain's hypothesis of the Karoo Formation having had a lacustrine origin, or, at least, having been partly formed in fresh or brackish waters. Besides some obscure casts of small Bivalves, Mr. D. Sharpe's *Iridinæ* (Trans. Geol. Soc. ser. 2, vol. vii. p. 188, and p. 277) are the only known shells from the Karoo beds. For remarks on the geological characters of this formation, which is either of latest Palæozoic (Permian) or earliest Mesozoic (Triassic) age, see Quart. Journ. Geol. Soc. vol. xxiii. p. 277; and vol. xxxi. p. 529, etc.

The form most nearly approaching *Estheria Greyii* in outline is *E. rimosa*, Goldenberg, Fauna Saræpont. foss., Heft ii. 1877, p. 44, pl. 2, fig. 16-18, from the Carboniferous beds of Saarbruck.

## II. Carboniferous Estheriæ.

1. *Estheria Dawsoni*, Jones. Plate III. Fig. 2.

In the Geol. Mag. Vol. VII. 1870, p. 220, Pl. IX. Fig. 15, we gave a drawing and brief description of a Nova-Scotian specimen of *Estheria Dawsoni*,[1] already noted and roughly figured by Dr. Dawson, F.R.S., in his Acadian Geology, 1868, p. 256, fig. 78*d*.

Thanks to Mr. Robert Etheridge, junior, F.G.S., we have now seen better specimens, though still only *casts*, of this species from Scotland.[2] These, collected by the Geological Surveyors of Scotland, and marked "B 1374 E" in the Museum at Edinburgh, are single and double valves, more or less flattened, scattered on the bed-planes of purplish, fine-grained, micaceous shale, in the Lowest Carboniferous series, east of Belhaven Bay, near Dunbar.

These Scotch specimens of *E. Dawsoni* give more perfect outlines than those previously figured. The subquadrangular shape, wide ridges (11 or 12), short anterior and long posterior moieties of the valves, and the sharp postero-dorsal angle, making the posterior margins somewhat sigmoidal, are characters in this species. No ornamentation is seen either on the casts or the impressions. Fig. 2*a*, right valve; Fig. 2*b*, left valve; internal casts. Magnified 10 diameters.

2. My friend, E. W. Binney, F.R.S., has communicated some specimens of *Estheria tenella* from Ciudad Real, Spain. In the Neues Jahrbuch für Min., etc., 1864, p. 656, *E. tenella* is quoted from Saarbrücken by Dr. E. Weiss; and in the vol. for 1869, p. 61, Geinitz mentions it as having been found in shale at Kargalinsk, Russia. He refers these and the Saarbrücken specimens to the Lower Dyadic (Permian) series.

3. Goldenberg, in his "Fauna Saræpontanæ fossilis,"[3] part 2, 1877, plate 2, figs. 9–18, illustrates *Estheria tenella* (Jordan), figs. 9–11; *E. limbata*, Gold., figs. 12–15; and *E. rimosa*, Gold., figs. 16–18; together with some *Leaiæ*, etc.

[1] *Estheria Adamsii* and *E. Peachii* were figured and described on the same occasion, *loc. cit.* Pl. IX. Figs. 1 and 17. *E. punctatella* had been already added to the list of Carboniferous *Estheriæ*, in the Trans. Geol. Soc. Glasgow, 1865, pl. i. fig. 3.

[2] Geol. Mag. Series II. Vol. III. p. 576.

[3] "Die fossilen Thiere aus der Steinkohlenformation von Saarbrücken," Heft ii.

### III. Some Triassic and other Estheriæ.

§ 1. New English locality for *Estheria minuta* (Alberti).

Some fine specimens have been obtained by Mr. T. J. Slatter, of Redditch, Worcestershire, in a purplish micaceous clay of the Upper Keuper Sandstone, and in the Lower Keuper Sandstone (Waterstones), near that place. For a general section of the New Red Sandstone of the district, see "Monograph of the Fossil Estheriæ," Pal. Soc., 1862, pp. 62, 63.

§ 2. Notices of *E. minuta* and some other *Estheriæ*.

*Estheria minuta* has been frequently referred to by the geologists of Germany since 1862, sometimes with new localities. In Alberti's "Ueberblick über die Trias," etc., 1864, it is accepted as a Crustacean, and correlated with *Posidonomya Albertii*, Voltz, and *P. Germari*, Beyrich, Zeitsch. deutsch. geol. Ges., vol. ix. 1857, p. 377); also doubtfully with *P. Wengensis* (from Dürrenberg), Giebel, Palæontol. Untersuch. (not *P. Wengensis* of Wissmann and Münster, Beitrage, etc., Heft 4, 1841, St. Cassian, p. 23, pl. 16, fig. 12, which is much larger). *Posidonomya nodocostata*, Giebel, Pal. Unters., pl. 2, fig. 7, is mentioned by Alberti as being probably an *Estheria*. Alberti's work is briefly noticed in the Geol. Mag. Vol. I. p. 167.

In the Neues Jahrbuch for 1864, p. 646, etc., Gümbel and Geinitz noticed some Permian (Dyadic) fossils from Thuringia, and among them a new *Estheria,—E. rugosa,* Gümbel. See Geol. Mag. Vol. II. p. 205.

Gümbel mentions *Estheria minuta* as a leading fossil of the Variegated and the Grey Keuper, in his work on the Bavarian Trias, "Die geognostische Verhältnisse des fränkischen Triasgebiets," 1865, pp. 53, 55, etc. So also does Frid. Sandberger in his "Beobachtungen in der Würzburger Trias," 1865, Wurzb. naturw. Zeitsch. vol. v. p. 221, etc.

In the Trias of the Taub Valley, Ph. Platz has found *E. minuta* in a dolomite, associated with a bone-bed, in the Lettenkohle series; N. Jahrb. 1869, p. 585.

*E. minuta*, var. *Brodieana,* is noticed by Fred. Römer as occurring in the Keuper at Paulsdorf in Upper Silesia; Zeitsch. d. geol. Ges. vol. xv. 1863, p. 702, etc., and in his "Geologie von Obernschlesien," 1870, p. 176, pl. 15, figs. 10 and 11; also previously in the Zeitsch. geol. Ges. vol. xv. (1863), p. 702, etc.

Frid. Sandberger, in the Verhandlungen d. k. k. geol. Reichsanstalt, Jahrg. 1871, in his remarks on "Die Estherien-Bank des Keuper in Südfrankreich (Département Gard)," p. 225, notes both *E. minuta* and *E. laxitexta,* Sandb., which is regarded as a variety of the *E. minuta* so abundant in the Lettenkohle.

*E. Mangaliensis*, Jones, is described by Geinitz as having been found in a bituminous shale (Brandschiefer), of Rhætic age, from San Lorenzo, Province of Mendoza, South America. See "Palæontograph.," Supplem. iii. Beiträge zur Geologie und Palæontologie der Argentinischen Republik; ii. Palæont. Theil, ii. Abtheil. Cassel, 4to. 1876, p. 3, pl. 1. figs. 1–6.

## IV. Fossil Ostracoda from Shotover, near Oxford.

§ 1. *Locality.*—Visiting the old stone pits of Shotover Common, March 16, 1874, in company with some students and Mr. H. Caudell, the late Professor Phillips' able assistant, and still attached to the Geological Department of the Oxford University Museum, the writer was present when Mr. Caudell picked up some fossiliferous pieces of the ironstone. One fragment of sandstone exhibits on its bed-plane the casts of a small *Unio* (*U. subtruncatus* ?), of a small *Cyrena* (*C. media* ?), and of numerous Ostracods; and a fragment of ironstone (from a crack in sandstone) bears numerous casts and impressions of small crushed *Paludinæ* (*P. Sussexiensis* ?), together with a few Fish-bones. These specimens are from the "Ironsands" just within the field-gate, near the "$h^2$" on the Geological Survey Map, on the Common, about 3 miles east of Oxford. They will be deposited in the University Museum.

The occurrence of so-called "Cyprides" in these Ironsands of Shotover and neighbourhood had been often spoken of, but was still doubtful; see Prof. Phillips's "Geology of Oxford," 1871, p. 412. Cavities left by the removal of the oolitic grains so common in the Ironstone look like the impression of these little fossils; and the partly exposed convex casts of the whorls of small *Paludinæ* often resemble their subovate valves. In the piece of very fine-grained, ferruginous, and micaceous sandstone containing the internal cast of a *Unio* and impressions of a small *Cyrena* (?), ornamented with delicate concentric ridges, numerous casts and impressions of different kinds of Bivalved Entomostraca are plainly visible.

It is not easy, however, to master the details of form and ornament of all the little Cypridiform Entomostraca present; inner moulds and exterior casts, more or less imperfect, being bad material to work upon, chiefly on account of the imperfection of the outlines of the imbedded specimens.

There seem to be five distinct recognizable forms, shown in the accompanying Plate by Figs. 3–11.

Besides the difficulty of defining outlines and other features, we cannot easily assign specific names to these forms, because we are not yet well acquainted with the limits of variation among the several Cypridiform species found in the Purbeck and Wealden formations.

§ 2. *List of the Ostracodous Entomostraca known in the Purbeck-Wealden Formation.*

The recorded species of *Ostracoda* known in the Purbeck-Wealden deposits are—

i.—*Cypris faba,* Sowerby (not Desmarest), "Mineral Conchology," tab. ccccIxxxv., 1824, p. 136-8; and mentioned also in the description of tab. xxxi., p. 78, as occurring in the Petworth Marble. This was afterwards named *Cypris Valdensis* by Fitton and Sowerby.

ii.—1. *Cypris Valdensis,* Fitton. Trans. Geol. Soc., ser. 2, 1837, vol. iv. pp. 177, 205, 228, 229, 259, 260, 297, 344, and 352, pl. 21, fig. 1.

In the *Weald Clay* of Kent, Sussex, Surrey, I. of Wight, and Dorset.

In the *Hastings Sand* of Kent, Sussex, and Isle of Wight.

In the Purbeck beds of South Wilts and Bucks.[1]

2. *Cypris tuberculata*, Sow. *Ibid.* pp. 177, 205, 228, 345, and 352, pl. 21, figs. 2*a*, *b*, *c*.

In the *Weald Clay*, near Hythe, Kent; near Atherfield and Cowleaze Chine, Isle of Wight; and at Punfield, Dorset.

3. *Cypris spinigera*, Sow. *Ibid.* pp. 229, 345, 352, pl. 21, fig. 3.

In the *Weald Clay* of Sandown Bay and Atherfield, Isle of Wight. Doubtfully in the *Purbeck Beds* of Portland, etc.

4. *Cypris granulosa*, Sow. *Ibid.* pp. 177, 260, 345, pl. 21, fig. 4.

In the *Hastings Sand*, Sussex ("Tilgate Forest," Mantell).

In the *Purbeck Beds* of South Wilts.

III.—Sowerby's figures, referred to above, have been copied again and again, in books on geology, by Lyell, Mantell, and others. In Lyell's "Elements of Geology," 1838, p. 348, figs. 184–187, woodcuts are given of *Cypris spinigera*, *C. Valdensis*, and *C. tuberculata*, after Sowerby's engravings.

In his "Wonders of Geology," 3rd edit. 1838, Mantell had a woodcut of *Cypris granulosa;* and in the 7th edit. he gave figures of *C. spinigera*, *granulosa*, and *Valdensis*. In his "Medals of Creation," 1844, he reproduced *C. Valdensis* and *C. granulosa*, together with *C. tuberculata*, Sow., which he divided into *C. Fittoni* (namely, fig. 2*a* of Sowerby's plate) and *C. tuberculata* proper (=fig. 2*b*, *c*). See also "Medals," 2nd edit., 1854, vol. ii. p. 527, Lign. 174, f. 2 and 3.

IV.—From the "Wealden" beds of Hanover, which, however, are related to the *Purbeck* rather than to the higher series, Fr. A. Römer described and figured some Bivalved Entomostraca in his "Die Versteinerungen des norddeutschen Oolithen-Gebirges: ein Nachtrag." 4to. Hanover, 1839. Thus:

p. 52.—1. *Cypris Valdensis*, Fitton, pl. 20, fig. 20*a*, *b*.
2. *C. oblonga*, R., fig. 21.
3. *C. striatopunctata*, R., fig. 22*a*, *b*.
4. *C. tuberculata*, Fitton, fig. 23.
5. *C. granulosa*, Fitton, fig. 24. This differs from the *C. granulosa* of Sow. and Fitton in being one of the ovate (not oblong) forms, and in having a beak and notch.

V.—Dr. W. Dunker, in his "Monographie der norddeutschen Wealdenbildung," 4to. Brunswick, 1846, gave a fuller account of the Hanoverian Entomostraca. Thus:

p. 59.—1. *Cypris Valdensis*, Sow., pl. 13, fig. 29*a*, *b*.
2. *C. lævigata*, Dunker, fig. 25.
p. 60.—3. *C. oblonga*, Römer, fig. 24 and fig. 26*a*, *b*.
4. *C. striatopunctata*, Röm., fig. 32.
5. *C. granulosa*, Sow., fig. 31*a*, *b*.
6. *C. tuberculata* (?) Sow., fig. 30*a*, *b*. This differs from Sowerby's *C. tuberculata* in being ovate and notched.
p. 61.—7. *C. rostrata*, Dunker, fig. 27.
8. *C. pinnæformis*, Dunker, fig. 28.

[1] *Hampshire* is included in the "Hastings Sand" Column, and *Kent*, *Sussex*, *Hampshire*, and *Isle of Wight* in the "Purbeck" Column of the Table, at page 352, evidently from inadvertence.

VI.—In the British Association Report for 1850, Transact. Sections, pp. 79-81, Prof. Edward Forbes defined several species of "Cyprides" as characteristic of the several divisions of the Purbeck beds of Dorset. He did not publish figures of these forms; but from his diagrams, used at the Museum of Practical Geology, Sir C. Lyell had reduced figures drawn for his "Manual of Elementary Geology," 3rd edition, 1851, p. 231. In the sixth edition of his "Elements of Geology," 1865, they are thus given:—

p. 378, fig. 368, *a.* *Cypris gibbosa*, E. Forbes. [Near *C. spinigera*, Sow.]
*b.* —— *tuberculata*, E. Forbes. [Near *C. tuberculata*, Sow.]
*c.* —— *leguminella*, E. Forbes.

These belong to the "Upper Purbecks."

p. 378, fig. 371, *a.* *Cypris striatopunctata*, E. Forbes. [? Fr. A. Römer.]
*b.* —— *fasciculata*, E. Forbes.
*c.* —— *granulata*, E. Forbes. [? *C. granulosa*, Dunker.]

These belong to the "Middle Purbecks."

p. 387, fig. 375, *a.* *Cypris Purbeckensis*, E. Forbes.
*b.* —— *punctata*, E. Forbes.

Belonging to the "Lower Purbecks."[1]

In the Mém. Soc. phys. Hist. nat. Génève, vol. xviii. part 1, 1865, MM. Loriol and Jaccard, in their "Étude géol., etc., Villiers-le-Lac," etc., notice an Ostracod as *Cypris Purbeckensis*, Forbes, p. 81, pl. 2, figs. 1—3; but it is difficult of determination on the small figure given.

VII.—By way of determining the specific identities or differences of the above-quoted fossil Entomostraca, we may take the leading characters of shape, and, especially the antero-ventral notch, and group the named forms accordingly. Thus—

*Sowerby's species.*—
- *C. Valdensis*, Fitton.
  1. Ovate-oblong, with strong notch (common form; Sowerby's figured specimen).
  2. Oblong, with a slight notch (Fitton's figured specimen).
- — *tuberculata*, Sow. Oblong, without a notch.
- — *granulosa*, Sow. Oblong, without a notch.
- — *spinigera*, Sow. Oblong, with a slight notch.

*Rœmer's species.*—
- *C. Valdensis*, Fitton. Ovate, with a strong notch.
- — *oblonga*, R. Ovate (with a notch, according to Dunker).
- — *striatopunctata*, R. Ovate (with a notch, according to Dunker).
- — *tuberculata*, Fitton. Oblong, without a notch.
- — *granulosa*, Fitton. Oblong, without a notch. (Without a notch according to Dunker.)

[1] In the "Catalogue of the Collection of Fossils in the Museum of Practical Geology," 1865, p. 254, the following are enumerated:—

*Cypridea fasciculata*,
—— *punctata*,
—— *Valdensis*,
*Cypris striatopunctata*,
—— *Purbeckensis*,
} Middle Purbeck.

*Cypridea tuberculata*,
—— *Valdensis*,
} Upper Purbeck.

Some of these names have evidently been adopted from Forbes.

*Dunker's species.*—
- *C. Valdensis*, Sow. Ovate and notched.
- — *lævigata*, Dunker. Ovate and notched.
- — *oblonga*, Römer. Elongate-ovate and notched.
- — *striatopunctata*, Römer. Ovate and notched.
- — *granulosa*, Sow. Ovate and notched.
- — ? *tuberculata*, Sow. Ovate and notched.
- — *rostrata*, Dunk. Ovate and strongly notched.
- — *pinnæformis*, Dunk. Long-ovate and notched.

*Forbes's species.*—None of the above-mentioned rough figures of Forbes's Purbeck species (page 105) show the *notch* in any degree; but, being drawn from various points of view, they are, of course, not satisfactory. In the Catalogue Foss. Mus. Pract. Geol., 1865, above quoted (page 105), *C. fasciculata, punctata, Purbeckensis,* and *tuberculata* are referred to *Cypridea*; *C. striatopunctata* and *Purbeckensis* being left with *Cypris.*

§ 3. *Remarks on the Wealden Ostracoda.*—Although these Entomostraca (Ostracoda) have been so generally referred to *Cypris,* it is very doubtful if any of them belong to that genus; in all probability, the majority belong rather to the *Cytheridæ* than to the *Cypridæ.*

The classification of these kinds of Bivalved Entomostraca runs thus.[1]

OSTRACODA: PODOCOPA.

| 1. Cypridæ. | 2. Darwinelladæ. | 3. Cytheridæ. |
|---|---|---|
| Cypris, | Darwinella, | Cythere, |
| Candona, | | Cytheridea, |
| etc. | | etc. |

Among the fossil Ostracoda of the Purbeck-Wealden strata there are three kinds of Carapace-valves.

A.—For the most part, the shape and structure of the valves are such as occur more especially with *Cythere* and *Cytheridea*; differing, however, chiefly in the hingement, which wants the *knurlings* of the latter and the *distinct teeth* of the former. In this respect they agree best with the forms of "*Cytherideis*" figured in Monogr. Tert. Entom., 1856, pl. 2, figs. 2, 3; but that is not a well-determined genus.

B.—Some of the Wealden Ostracoda are characterized by having an antero-ventral notch, more or less pronounced, especially in the more ovate forms of *C. Valdensis*; see Monogr. Fossil Estheriæ (Pal. Soc.), 1862, Appendix, p. 127, pl. 5, figs. 26 and 28. The presence of this feature induced M. J. Bosquet,[2] of Maestricht, to suggest that such species should be referred to a separate genus —*Cypridea.*

As a matter of convenience, it will be well to use this name, although as yet we do not understand the physiological value of the feature in question, which is certainly very variable in development. It may be concerned with the play of the lower antennæ; but it is

[1] Brady, Crosskey, and Robertson's Monogr. Brit. Post-Tertiary Entom., Pal. Soc. 1874, p. 110, etc.

[2] "Description des Entomostraces fossiles des Terrains tertiaires de la France et de la Belgique," Mém. cour. Acad. Roy. Belg., vol. xxiv. 1852; page 47 of the separate memoir.

not accompanied by a gaping of the valves, as in *Asterope* and other Cypridinads.

The characteristic feature of *Cypridea* is sometimes expressed only by a very small notch under a diminutive beak, or by even a slight indenture below and behind a thickening of the antero-ventral angle, as in Fitton's specimen of *C. Valdensis*, fig. 1, pl. 21, Trans. Geol. Soc., 2nd ser. vol. iv. Sometimes it is obsolete, or traceable only by a curvature of the inside edge. Sowerby's *C. tuberculata* and *C. granulosa* do not exhibit any notch in his figures, nor in our examined specimens. *C. granulosa* is also described by Sowerby as wanting the anterior "lobe" seen in *C. Valdensis*. His fig. 3*a*. of *C. spinigera* does show a linear trace of the notch, defining a marginal lobe. In a form closely related to *C. spinigera*, shown in the accompanying Plate (Figs. 9 and 10), we also see such an antero-ventral indentation. In Figs. 4, 5, 6, and 7 of our Plate, we have several conditions of a form related to Sowerby's *C. granulosa*, but with strong indications of notch and beak.

It is, of course, highly desirable to make as few generic divisions as possible of these thick-shelled, oblong or ovate-oblong Ostracoda of the Wealden and Purbeck beds. If "notched" in any degree, they may be referred to *Cypridea;* but it is often difficult to determine whether or no the notch be obsolete, reduced to a minimum, or altogether absent. Those without any trace of the notch, such as Sowerby's *C. tuberculata*, can be referred only to *Cythere* at present, unless, on the ground of their having otherwise a general resemblance, we venture to group them as *Cyprideæ* with an obsolete notch.

C.—There is, however, another and distinct kind of Ostracodous valve associated with the foregoing in the Shotover hand-specimen of Ironstone, and in the black Cyrena-shale of Hanover. These latter I wrongly correlated in the "Monogr. Foss. Estheriæ" (Pal. Soc.), 1862, Appendix, pp. 122 and 123, with *Cypridea Valdensis* (Sow.) and *C. oblonga* (Roemer), both of which are notched and beaked. After further consideration I am satisfied that figs. 30-34 in pl. 5 of the Appendix to the "Monogr. Foss. Esth." are closely related in form and structure to the recent *Candona candida* (Müller) and its allies; except, perhaps, that fig. 31 may be a *Darwinella*. They possess neither the notch nor the thick shell of the other Purbeck-Wealden forms (*Cypridea Valdensis*, etc.); but resemble very much some common *Cyprides* and *Candonæ*, and the less-known *Darwinella*, in their thin, shining, oblong, and apparently hingeless valves. Fig. 30, indeed, somewhat compressed, and drawn with the posterior end upwards, is probably the same as one found at Shotover, and may be regarded as a *Candona*; see further on. Fig. 31 is extremely like *Darwinella Stevensoni*, Brady and Robertson,[1] in outline. Figs. 32-34 may be three different *Cyprides* or *Candonæ*, as far as the valves indicate special features.[2] The importance of

[1] Monogr. Post-Tertiary Entom. 1874, p. 141, pl. 2, fig. 13.

[2] We may remark that fig. 25, on the same plate, representing *Candona Kotahensis*, from the Jurassic beds of India, has almost exactly the outline of the recent *Candona lactea*.

giving full credit to differences in valve-structure among these fossil Ostracods, whose recent representatives have their specific characters so largely marked in their limbs and soft parts, must always be borne in mind.

§ 4. *Description of the species from Shotover.*

1. Candona Phillipsiana, sp. nov. Plate III. Fig. 3. Internal cast of a left valve; magnified 20 diameters.

One relatively large, brown, shining, internal cast on the piece of fossiliferous sandstone from the Shotover Ironsand (see above, p. 103) indicates a right valve very similar to that of *Candona candida*[1] (Müller); subreniform or ovate-trigonal; thick and high in the posterior third; sinuate on the ventral, and obliquely convex on the dorsal edge; semicircular in front, and sloping boldly and obliquely, with a gentle curve, behind. The cast shows by slight marginal ledges, anterior and posterior, that the edge of the valve was widened by an inner free lamina, as in *Candona candida,* from which, indeed, this species is distinguishable chiefly by its greater height and blunter posterior margin.

It differs in form from the somewhat similar marine *Cytherideis nobilis,* Brady,[2] in its more tapering anterior third, less sinuous ventral margin, and far more oblique posterior outline.

Associating the name of the late Prof. John Phillips with this rare species, I dedicate it to the memory of that eminent geologist, one of the most earnest workers in the Shotover formation. Not long before his death he was much gratified by the information that real *Cypridæ* had been found in these Ironstones.

2. Cypridea verrucosa, et *var.* crassa, sp. et var. nov. Plate III. Figs. 4–7.

Valves oblong; convexity greatest at the posterior third. Surface pitted or coarsely reticulate, and bearing numerous tubercles, more particularly on the anterior and posterior thirds. Front edge of each valve semicircular; upper and lower edges nearly parallel, except in the advanced stage (or variety *crassa,* Fig. 4), in which the dorsal border is convex. Posterior margin rounded with elliptical curvature. Antero-ventral region either marked with a slight indenture and notch (Figs. 6 and 7), or strongly beaked (Fig. 5). In Fig. 4 (an imperfect and partly obscured individual), the two most forward tubercles to the left of the reader really belong to the massive lobe or beak, better seen in other fragments, and clearly but less strongly developed in Fig. 5. The gradation between these specimens seems to be complete.

Figs. 5, 6, and 7 approach very near to *Cythere* (?) *granulosa* (Sow.); but they show the special indenture or notch. Fig. 4 somewhat resembles *Cythere* (?) *tuberculata* (Sow.), but differs notably in shape and arrangement of tubercles.

[1] T. Rupert Jones, Monogr. Tert. Entom., Pal. Soc., 1856, p. 19, pl. 1, figs. 5 and 8: G. S. Brady, Monogr. Rec. Brit. Entom., Trans. Linn. Soc., 1868, p. 383, pl. 25, figs. 1–9: Brady, Crosskey, and Robertson, Monogr. Brit. Post-Tert. Entom., Pal. Soc., 1874, p. 135, pl. 2, figs. 29, 30.

[2] Trans. Zool. Soc. vol. v. (1866), p. 368, pl. 58, fig. 9.

Fig. 4. Partly imbedded and partly broken left valve.

Fig. 5. Shows the shell (broken) of a left valve.

Fig. 6. Shows a restored right valve from a hollow impression of exterior.

Fig. 7*a*. Shows the shell of a left valve, imperfect at the notch.

Fig. 7*b*. Shows the dorsal aspect of the same specimen.

These are all magnified 20 diameters.

*Cypridea verrucosa* has some resemblance to Lyell's figure of *Cypris tuberculata*, Forbes. But the latter shows no notch; and, if it be distinct from Sowerby's *C. tuberculata*, its name is pre-engaged.

3. Cypridea bispinosa, sp. nov. Plate III. Figs. 9 and 10.

Valves ovate-oblong, with indenture and notch, and with a coarsely pitted surface, bearing two sharp tubercles on the posterior third. This has a near relation to *Cypridea spinigera* (Sow.), but is more oblong in shape, having a straighter ventral edge; and instead of one central tubercle, it possesses two spinous processes, one on the postero-dorsal third of the valve, and one below and rather behind the middle of the valve.

Fig. 9 is restored (reversed) from a hollow impression of the exterior of a right valve. Fig. 10 is an internal cast of a left valve, showing traces of the muscle-spot. Both are magnified 20 diameters.

4. Cypridea Valdensis (Fitton). Plate III. Fig. 8, oblong var. of *C. Valdensis* (?); internal cast, showing muscle-spot. Fig. 11, outline of one of the common ovate and notched forms of *C. Valdensis*. Magnified 20 diameters.

The most common species found in the Wealden is that which Sowerby at first referred to Desmarest's *Cypris faba*, see Min. Conch., pl. ccccl xxxv. (1824), and which Fitton, with Sowerby, subsequently named *Cypris Valdensis*. From Sowerby's figure, and from the many particular Cypridiferous strata to which Fitton alludes in his memoir "On the Strata below the Chalk," etc., we know that the specially abundant form to which he refers has ovate-oblong valves, with a decided antero-ventral beak and notch. The form has been recognized also by Dunker and others as the *C. Valdensis*. The figure, however, given by Sowerby and Fitton in the above-mentioned Memoir, Trans. Geol. Soc., 2nd ser. vol. iv. pl. 21, fig. 1, is unfortunately not that of the common form, but of an *oblong* variety (if not *species*), with the notch and beak indistinct or nearly obsolete.

The ovate and strongly beaked form of *C. Valdensis* is present (though rare) in the Shotover sandstone (Fig. 11). It is narrower than the individual drawn in the "Monogr. Foss. Estheriæ," Pal. Soc., pl. 5, fig. 28; and approaches closely Dunker's figure of this species.

Among the badly preserved casts of valves in the iron-sandstone, is one of an oblong carapace (Fig. 8), possibly of the squarer form of *C. Valdensis*, since its surface shows no trace of tubercles. This is of considerable interest as showing marks of the *muscle-spot*. In this valve there were six small internal pits; three parallel in a vertical row, with one oblique mark in front and two oblique behind.

V. Ostracoda from the Subwealden Boring in Sussex.

1. Cypridea Valdensis (Fitton). Plate III. Figs. 13–15.

In a bluish limestone of the Purbeck series in the boring at Limekiln Wood, Netherfield, near Battle, Sussex, from the depth of 85ft., we have numerous specimens of single and double valves of Ostracoda, mostly *Cypridea Valdensis* of the common ovate form, *i.e.* tapering behind with a postero-dorsal slope. They are slightly indented at the posterior angle; and all have the antero-ventral notch. In all these particulars they differ from the *oblong* and slightly notched individual figured by Fitton. Some are shorter than others, and relatively higher; more like a peach-stone in outline; and are such as is represented in fig. 28, pl. 5, Appendix, "Monog. Foss. Estheriæ." Analogous forms, together with still squarer valves, occur in the hard thin shales of the Weald Clay at Peasemarsh, near Guildford, Surrey; but the notch is obsolete, or even absent, in these. These, with the specimen figured in Fitton's pl. 21, fig. 1, may be termed *Cypridea Austeni.*

2. *Cypridea granulosa* (Dunker). [Not *Cythere*? *granulosa*, (Sow.)] Plate III. Fig. 16; magnified 20 diameters.

This elongate-ovate, notched, and somewhat tuberculate *Cypridea*, answers well to Dunker's fig. 31*a*, *b*, pl. 13, *Cypris granulosa*, p. 60, of his "Monogr. Nordd. Weald." 1846. It is rarer in the Nettlefield Limestone than its associates.

3. *Candona*? vel *Cythere*? Plate III. Fig. 12 *a*, *b*; side and edge views of a carapace; magnified 20 diameters.

This small, neat, smooth carapace, elliptic-oblong in outline, with a straight dorsal (?) edge, also occurs in the Subwealden limestone at 85 feet. It is impossible to define its genus at present.

4. In specimens from the Subwealden Boring, with which I was favoured, in 1872-3, by Mr. H. Willett, F.G.S., and his colleagues in the enterprise, I found as follows:—

Depth 84 feet.—Greenish limestone, having smooth fracture, with a greyish granular Cypridiferous limestone in cracks of the denser portion. *Cypris*? (one) subtrigonal and very delicately striolate, in the granular portion. *Candonæ* (?) suboblong and smooth, on a bed-face of the greenish portion.

Depth 85 feet.—Greenish-grey earthy Cypridiferous limestone, rich with *Chara* also.
*Cypridea Valdensis*, *C. granulosa*, etc. (See above.)
*Chara* seed-vessels and stems.

Depth 92 feet.—Grey earthy Cypridiferous limestone, consisting of layers of Cyprids with intercalated thin seams of hard shale; and with granular (Cypridiferous) limestone filling cracks.
*Cythere*?—oblong (new), and another?
Minute black vegetable stems.

Depth 96 feet.—Greenish-grey Cypridiferous limestone, consisting of alternate layers of Cyprids and shale.
*Cythere*? oblong. (Like that at 92 feet.)

Depth 103 feet.—Dark-grey earthy limestone, with minute, black concretionary (?) and vegetable (carbonized) specks.

Depth 136 feet.—Grey, hard, Cypridiferous, banded limestone, like those from 92 feet and 96 feet, but harder, and with its structure more obscure. Holes and cracks in it have been filled with a more granular limestone.

5.—In a black shale from Archer Wood, near Battle, also communicated by Mr. Willett, F.G.S., were numerous specimens of the ovate *Cypridea Valdensis*, but not well preserved.

## III.—Geology of the Channel Islands.

By J. A. Birds, B.A., F.G.S.

(Continued from p. 86.)

### *Part II.—Post-Pliocene Geology.*

FROM the sandstone (*i*), which Professor Ansted asserts, though without giving his reasons, to be "no doubt modern," and to have been "deposited before" [just before?] "or during the last great elevation," down to the superficial clays and sands, there is not a scrap of any other Secondary or Tertiary rock *in situ* to be found on any of these islands. We leap at once from this sandstone to clays and sands of Post-Tertiary date. Mr. Duncan, in his History of Guernsey (edit. 1841, p. 513), says that "flint and chert nodules, containing impressions of shells, etc., are frequently discovered beneath the soil in places which preclude the probable transport by the hand of man."

"This," he adds, "is especially the case on the denuded summit of the gneiss of the South of Guernsey." I conclude he means in the brick-clays and sands covering the S.E. corner of the island. I have myself traced these clays, etc., from near the Doyle Column on Jerbourg Point, round by St. Martin's and St. Andrew's Churches, to the Foulon Cemetery, and the Amherst Road above St. John's Church, in St. Peter's Town; and I found two or three small specimens of chalk flints in the clay associated with pebbles and fragments of gneiss, granital, quartz, and other rocks of the neighbourhood. The island of Sark, in the same manner, is covered at various points with a coating of clay containing stones, generally derived from the underlying rocks; but, at the old mine-heaps in Little Sark, I found, beside these, a fragment of amygdaloid, and another almost perfectly hexagonal fragment of basalt, not, so far as I know, derived from any of these islands. Alderney, again, is said to contain almost inexhaustible supplies of brick-clay, which has probably a similar derivation.

Jersey, also, is covered in many places with brick-clay and sand, especially around St. Helier's; but no chalk flints have been found in these deposits. Upon the shores, however, of all the islands, without exception, chalk flints occur, and in some places very abundantly. Dr. MacCulloch in 1811 says that he "picked up flints upon the beach at Alderney," and Professor Ansted calls attention to a singular profusion of chalk flints often of large size in Port-Saie, on the N.E. of Jersey; and also on the beach at Grouville Bay; and he appears to think, from their being found chiefly in the neighbourhood of the newer conglomerate (*h*), that they may possibly have been derived from it. They have not, however, he admits, ever been seen *in situ* in the conglomerate itself. I can add that the flints are to be found, though not in equal abundance, in St. Clement's Bay and the Grève d'Azette on the south, and in Bouley Bay on the north—in fact, on all the shores of the eastern half of Jersey. They are wanting, Professor Ansted says, on the western side. In Guernsey, however, they are plentiful in all the bays on the west and north-west—in Rocquaine—but especially in Vazon and Cobo Bays, and Grand Havre; while they are also to be found in Bellegrève Bay on the east; and even, though sparingly, in Moulin Huet and Saint's Bay on the south. They occur too in Icart Bay and at Epercherie in Sark.

Now what is the origin of all these coverings of clay and sand, and of the chalk flints? It is very improbable that any of it is true Boulder-clay, belonging to the first continental period. But few boulders, and no "scratched" blocks, or stones, have been observed in it. Nor are there any of the other usual glacial signs to be seen upon the islands. Nor again, Prof. Ansted says, "is there any gravel consisting of transported pebbles of foreign material" to be found there. Much of the clay and sand may have been derived from the decomposition of the underlying porphyries and syenites. Much, however—especially that in the S.E. of Guernsey—has the appearance of a genuine drift; and, unless a more probable origin can be suggested, I should be inclined to refer it to the intraglacial period of submergence; to which also I would refer the presence of the chalk flints upon the shore.

The question, however, arises: how could this be if, as exhibited in the "Map of the supposed submergence of the British Isles and N.W. of Europe,"[1] the South of England and N.W. of France, etc., had been dry land? We might indeed suppose that ice coming from the north, and loaded with clay and flints, etc., occasionally made its way through the Straits of Dover, or up the Channel, and deposited its freight around the Channel Islands; and this would account for the flints now found on the shores, but it would not account for the clays containing flints, as in the S.E. of Guernsey, 200 or 300 feet above the sea.

Since 1846, however, when E. Forbes first expressed the opinion that "the South of England and Ireland were in all probability unsubmerged during the Glacial epoch,"[2] a certain amount of evidence has been gathering which seems to show that this opinion must be modified, and that at all events the greater portion of the South of England, as well as perhaps the N.W. of France and Belgium, were submerged in the interval between the two continental periods.

For example, in 1853, Mr. Trimmer, the discoverer of the drift on Moel Tryfaen, pointed out that there were three sets of gravels south of the Thames, viz. at Shooter's Hill, Dartford, and Rochester, the northern origin of which was proved by their contents.[3] Among other northern stones he found a peculiar kind of quartzose pebbles, which had previously been traced by Dr. Buckland from their original home in a Triassic conglomerate on Cannock Chase, down the valley of the Avon into Worcestershire; and thence, over depressions in the Cotteswold Hills, to Oxford, and so down the valley of the

[1] Antiquity of Man, p. 276.
[2] Mem. Geol. Surv. vol. i. p. 364.
[3] Quart. Journ. Geol. Soc. vol. ix. 1853, part iii. of Mr. Trimmer's paper.

Thames as far as Hyde Park.[1] These gravels Mr. Trimmer regards as contemporaneous with the rolled gravel and upper erratics of the counties north of the Thames, *i.e.* of Middle Glacial age.

Mr. Trimmer again, from the presence of Boulder-clay at Youghal in the South of Ireland, and from grooved and scratched blocks in the south of Co. Kerry, infers that "the South of Ireland was subject to glacio-marine operations;" and he adds that "the boundaries which have been assigned to the Boreal Ocean in order to explain the relations of the existing fauna and flora of the British Isles[2] will require considerable modification," that is, as I understand him, an extension further south.

Again, the same writer quotes from Rutter's "Delineation of Somersetshire" (1829) to the effect that "a bed of rolled gravel, associated with the bones of diluvial quadrupeds, was then to be seen at the mouth of the Avon;" and further, that ridges of sand and shingle "are occasionally found in Somersetshire rising up through alluvial deposits;" *e.g.* at Yatton, where a section of these was to be seen in the railway cutting.[3] Lastly, Mr. Trimmer has described a bed of gravel on the summit of Clevedon Down, 300 feet above the sea, which he considers to be of Post-Pliocene age. The late Prof. Beete Jukes was, perhaps, deceived as to the existence of glacial markings in the valley of the Exe;[4] but Mr. G. Maw has pointed out a deposit of what he believes to be Boulder-clay at Fremington, near Barnstaple,[5] and he is supported in this opinion by the Rev. W. S. Symonds, who believes that "it may be a glacial Till like that of Bovey Tracey."[6] This Till itself again is another argument in favour of the submergence of a considerable portion of the South of England. At Petrockstow, in the centre of Devonshire, there is said to be an isolated bed of Dartmoor gravel, which has travelled twelve miles from its source. This, too, is identified with the glacial clay of Bovey Tracey. Chalk flints, I believe, are to be found more or fewer on all the coasts of Cornwall and Devonshire. I have myself found them along the coast of North Devon as well as on Paignton Sands, near Torquay, and under Petit Tor, St. Mary Church, in the south. At Newton Bushel, a few miles north of Torquay, there is a very remarkable deposit of flint-gravel, 100 and more feet above the sea, which alone would imply the recent submergence of this part of the country to at least that depth. These flints, as well as some Greensand gravel on the opposite side of the valley, are, apparently, relics of a mass which has floated from the north. So much for the evidences of submergence, of at least a great portion of the South of England, in the intraglacial or intracontinental period.

What similar evidences may exist of submergence of the north and north-west of France and Belgium I am not prepared to say. Some

[1] Trans. Geol. Soc. vol. v. p. 251.
[2] Mem. Geol. Surv. vol. i. plate 7.
[3] Quart. Journ. Geol. Soc. vol. ix. pp. 282-286.
[4] Geol. Mag. Vol. II. p. 473, and Geol. Quart. Journ. vol. xxiv. 1868, p. 3.
[5] Quart. Journ. Geol. Soc. vol. xx. 1864, p. 445.
[6] Records of the Rocks, by Rev. W. S. Symonds, p. 278.

years ago I ventured to describe, in this MAGAZINE, a bed of chalk flints near Spa, in Belgium,[1] which I imagined might have been deposited by floating-ice at the epoch in question. If this was the case, and supposing the submergence to have been uniform and general, it must have been to a depth of 1500—2000 ft., which would have reduced all Europe north of the Alps and Pyrenees to a sea, with only a few mountain or hill ranges—as the Harz, the mountains of the Black Forest, the Vosges, the hills of Central France, and some few summits in Brittany, remaining as islands in the midst of the waters.

This bed of chalk flints, therefore, I am unwilling to cite as evidence of submergence; although it is not necessary to assume that the depression was either uniform or general.

But to return to the question of the clays, etc., and flints of the Channel Islands, and the probable origin of their presence there.

Only two or three causes, it is evident, are probable or possible. Either (1) they are the relics—and meagre ones indeed—of a former extension of the Chalk or some later formation containing flint-gravel upon or near the spot; or (2) they must have been transported from a distance, and that either by oceanic currents, or by ice: and of these two alternatives the latter is surely far the more probable.

It is not necessary indeed, as was said above, to suppose that the South of England was submerged so as to allow of the passage of ice-rafts in a direct line from the north; these might still have wandered up and down the Channel from the S.W. or N.E., occasionally bringing freights of chalk and flints with them. That such ice-ships were wafted, even from the south, has long since been inferred from the presence of erratic blocks on the coast around Selsea Bill and Pagham, which are believed to have come from Brittany or the Channel Islands. These blocks, indeed, are adduced as evidence of an ancient coast-line existing there during the intracontinental period—and therefore of the non-submergence of the South of England. No one, however, can say how far such a coast-line might have extended east and west; and, therefore, it is scarcely an argument against a general submergence of the country south of the Thames and the Bristol Channel such as I have been advocating—in which case, it is obvious that the amount of chalk and flints borne southwards, *e.g.* over Salisbury Plain, and between it and the Mendips, would be very greatly increased. Also, if the submergence extended to the Channel Islands, it would account for the clays, etc., containing flints (on the summit of Guernsey), which would not be accounted for otherwise.

The evidences of elevation of the British Isles during the first and second continental periods, and of submergence in the intermediate time, are clear and numerous, as regards the country north of the estuary of the Thames and the Bristol Channel; and as yet they are, and perhaps always will be, few and obscure to the south of that line; but is it reasonable to suppose such enormous movements

[1] GEOL. MAG. 1866, Vol. III. p. 501.

—speaking roughly, some thousands of feet of elevation above—2000 ft. depression below—600 ft. again elevation above the present level, in the north; and that the south should have shared in the first and the last of these movements, as it must have done, for England to be united with the Continent, but that it should have had no corresponding share in the intermediate one? Surely this is highly improbable *à priori*. There cannot be any magic in the line between the mouth of the Thames and the Bristol Channel that it should present an effectual obstacle to the continuation of a movement which must have been due to deep-seated and wide-spread causes operating within the crust of the earth.

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## IV.—Micrasters in the English Chalk—Two or more Species?

By C. J. A. Meÿer, F.G.S.

To the student of Cretaceous palæontology there could be suggested, probably, no more puzzling question than that of the determination of the species of the genus *Micraster*. It seems not unlikely that Professor Forbes was of this opinion when, in 1850,[1] he reduced to varieties of a single species—that of *Micraster cor-anguinum*—no fewer than seventeen previously supposed species, or subspecies, of the genus. It is true that, out of compunction, perhaps, for such wholesale slaughter, he forthwith established one new species, the *Micraster cor-bovis*, and pointed out the probable existence of another —"a small *Micraster* with a very elevated extremity from the Chalk of Lyme." This, however, seems scarcely to make up for the absorption or obliteration of all but one of the previously described species. And, seeing that several of these so-called varieties of *Micraster cor-anguinum* are recognized as species by many continental palæontologists, it becomes an interesting subject for inquiry whether our English Chalk does not contain more than one species in addition to the recognized *Micraster cor-anguinum* and *cor-bovis?*

The genus *Micraster*, as defined by Agassiz, appears to have met with very general acceptance. Its stratigraphical range is brief. Its extreme of variation, although considerable, is not great as compared with that of many other genera. Whence then has arisen so wide a difference of opinion in respect to the number and value of its species?

This question has not unfrequently occurred to me when seeking some palpable distinction between specimens of *Micraster* seemingly different. The answer appears to lie in the smallness of the difference between one species or specimen and another.

It is embarrassing, certainly, to find that in a given series of specimens one should feel compelled to recognize either several species or variations only of a single species according to the mode of arrangement of the specimens, and yet such appears to be practically the case. Arrange the specimens irrespectively of stratigraphical considerations, as Forbes appears to have done, and it is possible to obtain such a graduated series as shall apparently obliterate all marked distinctions of length, breadth, and height.

[1] Mem. Geol. Surv. decade iii.

Arrange them, as Nature has done, stratigraphically, and one cannot but allow of certain distinctions not otherwise so readily apparent. In the one case, however, one will have, unintentionally, grouped together specimens in which the position of the mouth, or peristome, will be as different as appears in the outline figures 1 and 2.

FIG. 1.

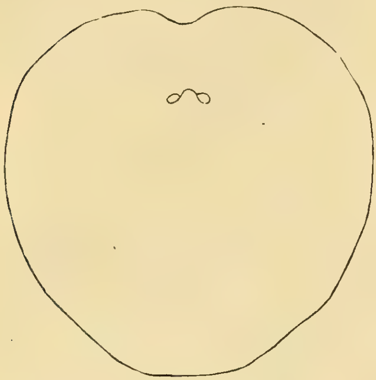
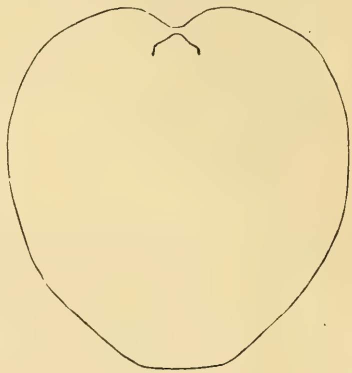


FIG. 2.



In the other, or natural, arrangement, the position of the mouth will be found to be almost constantly the same in specimens from the same geological horizon, and widely different only between those from different horizons. And it will be observed that a corresponding variation takes place in respect to the position of the apical disk. In the natural arrangement of the specimens one obtains, in fact, an almost regular gradation in the relative positions of the mouth and apical disk (as shown in Fig. 3), and a gradation also, more or less regular, in other minor points of difference.

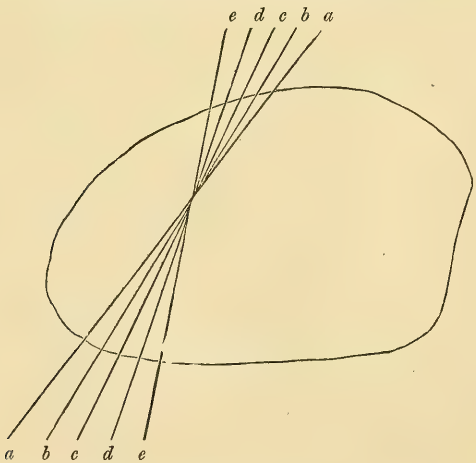



FIG. 3.

FIG. 3.—In which the changing relative positions of the mouth and apical disk are indicated by the lines *a-a*, *b-b*, etc.

Practically then the *Micrasters* of one horizon in the Chalk differ from those in the preceding or succeeding horizon in a manner which is suggestive rather of progressive development than of simple variation.

But there are other less apparent, yet not less actual, differences between the various forms or species of *Micraster*. One of these consists, as has been well shown by Prof. Hébert,[1] in the arrangement of the granules on the petaloid portion of the dorsal ambulacra. Another difference may be observed in the ornamentation of the base of the test. Yet another in the number of plates impinging on, or notched by, the anal opening, which varies apparently from seven in the earlier species to five and sometimes four only in the later forms, or species, in the English Chalk. Independently, therefore, of differences of height, length, and breadth, which vary to some extent in the same species, and setting aside *Micraster cor-bovis,* and the extreme form of *M. gibbus* now generally recognized as an *Epiaster,* there would appear to be greater constant differences between the *Micrasters* of the English Chalk than is consistent with simple variation.

Have we then indeed but two species of *Micraster* in the English Chalk? For myself I am inclined to the opinion that we have not two species only, but several species, as many possibly as six or seven. What these represent may possibly form the subject of a future note.

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## V.—Palæontological Notes.

By R. Etheridge, jun., F.G.S.

(Continued from Vol. IV. N.S. p. 320.)

1. Dentalium ingens, de Koninck, and D. ornatum, de Kon. (Descrip. Animaux Foss., pp. 317 and 318, t. 22, f. 2 and 3).—The first of these species has been often recorded from Scotch Carboniferous rocks, but, so far as I am aware, the second is new not only to Scotland, but in British Carboniferous rocks generally. Specimens were forwarded to Prof. L. G. de Koninck, M.D., who was kind enough to confirm my determination. Our specimens of both the above species show the growth striæ of the shell to have been waved, like the septa of some Orthoceratites, consequently I presume the anterior apertures would be similar. In Prof. de Koninck's figures the striæ are oblique, and the anterior aperture is described as oblique. *D. ingens* is from the shale above the Skateraw Limestone (L. Carb. Limestone Group) at East Barns, near Dunbar, and *D. ornatum* from shale above the Roscobie Limestone at Roscobie.

*Collector,* Mr. James Bennie.

2. Rhynchonella or Orthis, n. sp. (?).—A very peculiar Carboniferous Brachiopod has lately come to light; unfortunately we have only one specimen at present, and that not quite perfect about the hinge. The shell in question is minute, about the size of a small

[1] Mem. Soc. Geol. de France, 2 ser. tom. v. pl. xxix. fig. 14-19.

pea, and very closely resembles in form and general characters the Silurian *Orthis biloba.* We have only one valve, the ventral (?), which is markedly bilobed, with numerous close fine longitudinal ribs. The specimen was forwarded to Mr. T. Davidson, F.R.S., who, on returning it, said, "In outward shape, as you justly remark, it much resembles *Orthis biloba* from the Silurian rocks, but you say your specimen is Carboniferous. . . . . . Unfortunately the hinge-line, or part close to the hinge, in the interior, is not well preserved, so that it is difficult to determine whether it is an *Orthis* or a *Rhynchonella.* . . . . If it were Silurian, I should almost take it to be *Orthis biloba.*" It will perhaps be best to catalogue it as *Rhynchonella?* sp., until the discovery of further specimens shall enable us to arrive at a more definite conclusion.

*Loc. and Horizon.*—Skateraw, near Dunbar, in Lower Carboniferous Limestone shale.

*Collector*, Mr. J. Bennie.

3. Pentremites, sp.—So far as I am aware, this genus has not been recorded from the Scotch Carboniferous series. We have in the collection of the Scotch Survey a portion of a minute ambulacrum, washed amongst other small things from a sample of shale by Mr. Bennie. The form of the ambulacrum when perfect would be lanceolate, with a minute flexuous ambulacral groove. The latter is crenulate on the sides, giving off short alternate lateral grooves which communicate with sockets. From the slits or holes in the lateral margins of the ambulacrum run in other grooves, which lead to larger sockets than those terminating the branch ambulacral grooves, and set alternately with the latter. The under-surface of the ambulacrum is flattened. These features are so like those described by the late Mr. Billings in the ambulacra of *Pentremites pyriformis* (Canadian Pal. Foss. vol. ii. pt. i. p. 114), that I think it very probable the small ambulacrum in question is that of a *Pentremite.* It is quite different from that of *Astrocrinites Benniei* (mihi).

*Loc. and Horizon.*—Carlops Quarry, Peebleshire, shale over the Carlops Limestone, Lower Carboniferous Limestone Group.

*Collector*, Mr. J. Bennie.

4. Spirorbis spinosa, de Koninck (Descrip. Anim. Foss. Terr. Carb. Belgique, p. 58, t. G. f. 8, a–c).—This species occurs in the Scotch Carboniferous system sparingly. I recognized a few examples in some washings obtained at Gair, Lanarkshire, a few years ago by Mr. Bennie, from shale above the Gair Limestone (Up. Carb. Limestone Group), and have since seen it from one or two other localities.

5. Chonetes polita, M'Coy.—Both M'Coy (Brit. Pal. Foss. p. 457, t. 3*d*, f. 30) and Davidson (Mon. Brit. Carb. Brachiopoda, p. 190, t. 47, f. 8–11) describe and figure this species as possessing a smooth shell. I find, however, that many examples from localities in the neighbourhood of Edinburgh show that the shell was marked longitudinally with faint, semi-effaced, flattened ribs or striæ, usually much more marked towards the front margin.

*Localities and Horizon.*—Shale above the No. 1 Limestone of the Mid-Lothian Carboniferous area at Fernie-hill, Gilmerton, near Edinburgh; Cousland and Darcy Quarries, near Dalkeith, and numerous other localities in the Lothians and Fife.

*Collector*, Mr. J. Bennie.

6. HYALONEMA, sp.—As supplementary to the localities given by the Messrs. Young for *Hyalonema parallela*, M'Coy, in their interesting paper on that form (Annals Nat. Hist., Nov. 1877), I can afford the following in the East of Scotland where the "rope" may be obtained in fine condition, viz. Petershill and Galabraes Quarries, near Bathgate; Tartraven Old Quarry, near Linlithgow; Charlestown Quarry, near Inverkeithing; Roscobie Quarry, near Dunfermline; Laddedie Quarry, near Cupar; Airfield, near Cousland by Dalkeith. From two other localities we have similar "rope"-like bodies exposed on the surface of some weathered shale which appear to differ from the typical *H. parallela* in certain particulars. They are of considerable length, forming long undulate bundles, the rods being far finer than in *H. parallela*, quite hair-like and apparently retaining their size throughout the whole mass in a much more constant manner than in the described form. I have not yet seen sufficiently complete examples of *H. parallela* to say whether this is only a portion of an example of that species or a distinct form. I had, however, provisionally labelled the specimens in question *H. Youngi*, after Mr. J. Young, F.G.S., who has been chiefly instrumental in working out the affinities of the long-known *Serpula parallela*, M'Coy, and as such I shall keep them until further evidence is acquired.

*Locality and Horizon.* — Hillhead and Whitfield Quarries, near Macbiehill Station, shale above the No. 1 Limestone, Lower Carboniferous Limestone Group.

*Collector*, Mr. James Bennie.

## REVIEWS.

I.—AUS IRLAND. VON DR. ARNOLD VON LASAULX. Mit 26 Abbildungden in holzschnitt, 1 Karte von Irland, und 1 Tafel in Lichtdruck. (Bonn, 1878.)

IN the summer of 1876, Dr. von Lasaulx, in company with his colleague, Dr. Ferdinand Roemer, of the University of Breslau, paid a long-meditated visit to "the Green Isle," and in the handsome volume before us we have the recorded impressions of one of the travellers, not only on the physical and natural history of the country, but on its inhabitants and institutions. It is certainly highly to the credit of the author, and illustrates his industry in observing the scenes around him, and in collecting information from every available source, that within the space of a three-weeks' tour he should have succeeded in making himself so fully acquainted with the scenery, physical features, and geology of the country, together with the specialities of its inhabitants. As regards the latter, we think he is on the whole unduly depreciatory, and scarcely does justice to the great strides which art and civilization have made within the existing generation; with regard to the former, he is generally pleased, sometimes delighted and enthusiastic.

Having spent a few days in Dublin, examining the museums, the churches, and public buildings, including those of the University, which he highly admires, and having provided themselves with geological maps, guide books (not always reliable), and Geological Survey "Explanations" (which *are* always reliable), our travellers take the train to Killarney, where they spend several days exploring the lakes and mountain passes, and climbing Mangerton (2754 feet), from which they enjoy a panoramic view which is graphically described. We have very minute descriptions of the geological structure of the lake district and mountains; and the author recognizes in the grand E. and W. flexures of the mountains of Kerry, the prolongation of those which have disturbed and contorted the Carboniferous and Devonian rocks of Belgium and North Germany. At p. 75 we have a table, which is intended to bring into parallelism the Lower, Middle, and Upper Devonian beds of the Eifel, the neighbourhood of Aachen (Aix-la-Chapelle), Westphalia, and the South of Ireland; and certain beds of nodular limestone and calcareous shale observed on the flanks of the mountains near Muckross are placed (with some hesitation) as the representatives of the "Cypridinen-Schiefer, Goniatiten-Schiefer, und Cuboides-Kalke, etc.," of the Eifel. We fear, however, such a comparison cannot be maintained. The beds which Prof. von Lasaulx refers to are really Carboniferous, nor are there any marine limestones in the Old Red series of the South of Ireland. On the volcanic phenomena of "the Devil's punch-bowl," and the characters of the old lavas and ash-beds, our author's observations are accurate and suggestive.

The appearance of some native women accompanied by a lad proffering our travellers some of the "wine of the country," and thus described: "Die Gestalt und die Gesichtsbildung dieser Frauen war auffallend. Es waren feingebaute, schlanke, aber doch volle Figuren, die nicht ohne eine gewisse Eleganz baarfuss über die rauhen Blöcke schritten, mit tiefschwarzen, glänzenden Haaren und dunkelbraunen Augen," etc., gives our author an opportunity for an ethnological *excursus*, in which he draws a very clear distinction between the Celtic and the "Milesian" inhabitants of this part of Ireland, the latter being the descendants of the Spanish settlers who from time to time colonized the country. From Killarney the author returned to Dublin, and from thence explored some of the glens of Co. Wicklow, including that of Glendalough, with its ancient ecclesiastical buildings. With the minerals in the metamorphic rocks bordering the granite, and those in the granite itself, the author is greatly interested; but time, apparently, did not permit of his paying much attention to the very striking glacial phenomena of that region.

The remaining portion of the volume is devoted to the North of Ireland. Having accepted the proffered hospitality of the noble owner of Florence Court, the author had an opportunity of examining Lord Enniskillen's splendid collection of fossil fishes, with which that of Sir Philip Egerton is alone comparable. A list of the genera and species drawn up by his Lordship has already appeared in the GEOL. MAG.[1] In this district he had an excellent opportunity of examining the succession of the Lower Carboniferous rocks, from their base along the shores of Lough Erne, where they repose on the Old Red Sandstone, up to the Millstone-grit ridge of Cuilcagh, which rises 2,187 feet above the sea. The limestone in this district is rich in coralline, and crinoidal remains; *Pentatrematites Derbiensis, Platycrinus,* etc., and the author records the occurrence of *Amphoracrinus Gilbertsoni,* in the cliffs of the upper limestone which rise boldly above Florence Court Park. Need we say, that with Lord Enniskillen and his family our author is fairly captivated, and that he bids farewell to the hospitable "Schloss," with feelings to which he gives expression in the following passage: "Als wir uns in der Halle der irischen Riesenhirsche herzlich von unsern gastlichen Wirthen verabschiedeten, trugen wir eine unauslöschliche, freundliche Erinnerung an das grüne Florence-court und seine edlen Bewohner von dannen. Mögen sie, wenn dieses Blatt ihnen zu Gesichte kommt, es als ein Zeichen unserer Verehrung ansehen und der deutschen Gäste aus dem fernen Osten wohlwollend gedenken" (p. 135).

From Enniskillen the author and his companion proceed to the north-east, travelling along the valley of the noble river Foyle to Londonderry, and thence proceeding to the Antrim coast, with the scenery and geology of which he is greatly delighted. Visiting the town of Antrim on his way southwards, he examines the celebrated "Round Tower" of that place, of which a picture is given (p. 161), as well as the trachytic district of Tardree Hill; and here the author justifies his high reputation as a mineralogist, by the discovery of that rare form of silica, called "tridymite" by Vom Rath, which appears to be abundant in the drusy cavities of the trachytic lava. Further on his way, he visits the celebrated plant-bearing beds of Ballypalidy of Miocene age; and after a short stay in Belfast, finally takes his departure for Scotland, to be present at the meeting of the British Association.

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II.—THE PHYSICAL GEOLOGY AND GEOGRAPHY OF IRELAND. By E. HULL, M.A., F.R.S., Director of the Geological Survey, Ireland, and Professor of Geology in the Royal College of Science, Dublin. Post 8vo. with 2 coloured maps and 26 wood engravings, pp. xvi. and 291. (London: Stanford, 1878.)

(*First Notice.*)

WE have often wondered why our Geological Literature contained no general key to the structure and features of Ireland. That the 'Green Isle' could boast of more than one 'son of the hammer' who was competent to lay such a summary before his brother geologists, we knew, not only from the enjoyment of personal intercourse, but from an acquaintance with their published labours. Yet we had it not. More than five years since, the

[1] See GEOL. MAG. 1869, Vol. VI. p. 556.

admirable *Physical Geology and Geography of Great Britain,* by Prof. Ramsay, had reached its third edition, and had been entirely remodelled; while North Britain could point with just pride to Geikie's interesting *Geology and Scenery of Scotland.* True the detailed map of Griffith, and the many reductions of, and improvements on it, which have resulted, formed in themselves excellent, and to a large extent sufficient, guides to a knowledge of the general structure of a country, essentially so simple as that of Ireland. And we have no doubt some feeling of this kind, and a desire that one who had already done so much for the Geology of Ireland, should, if he himself wish it, have the opportunity of making that country still more his own kingdom, by adding to his map a general description, kept several from attempting a task for which they felt their old master and guide was so vastly more competent than they. But whatever the cause, it has been reserved for Prof. Hull to supply this want in the little volume now before us.

Like all contributions of the author, the work is carefully compiled, and is a singularly full though much compressed statement of facts, given in the simplest language, with, we rejoice to say, very few attempts at oratorical effects, or fine writing. It thus carries with it the conviction of truth and sincerity which we are always disposed to concede at once to a simple and full exposition of facts: it is, in reality, so essentially dependent for its conclusions on the abundance of its details, that no single or hasty reading will suffice to the student.[1]

The author presupposes, wisely, we think, an acquaintance with the elementary principles of the Science of Geology on the part of his readers, and, therefore, passes at once to an enumeration of the various formations which occur in Ireland, the extent and position of the areas they occupy, and their mutual relations. To the discussion of these questions the first of the three parts into which the book is divided, is given. This is also by a good deal the longest and most detailed division, occupying 116 pages. The Physical Geography occupies the second part (pp. 117-210); and the third part (pp. 211-272) is devoted to the 'Glaciation of Ireland.'

A general summary of observations over a wide area, so as to give a comprehensive idea of the relative structure and history of the different points, offers no fitting opportunity for the detailed discussion of any special views, or the exposition of any novel speculation, and we shall therefore better elucidate our author's work by a very brief *resumé* of the information given, than in any other way.

[1] With this fullness and care, we notice also several things which convey to our mind a distinct impression that the work has been hastily written and too hastily printed. There are errors of grammar, errors and confusion in the spelling of names, and phrases and idioms which, though perhaps intelligible, are certainly not elegant, which a very little more care and time would have avoided. We notice these little defects at once, not as wishing to convey the idea that the real value of the work is diminished by such blemishes, but because we feel confident that a second edition will soon be called for, and we would gladly see even these little blots polished out.

The geological structure of Ireland, on the whole, is singularly simple. Over more than nine-tenths of the total area we find no rocks of a date later than Palæozoic (Upper Carboniferous, with a trace of Lower Permian, if these be Palæozoic) until we come to the more recent Tertiary, post-Pliocene, or drift deposits, as the author calls them, that is, we have no representatives of any but the oldest and the newest groups of rocks; while even in the remaining small area in the north-east of Ireland, although some of the Mesozoic rocks are represented, there is still an immense period (including all the time represented in the closely adjoining counties of England, by the wide-spread, and as regards both the agricultural wealth and the loveliest scenery of the country, all-important groups of the Lias, except the lowest beds, the entire series of the Oolites, the Wealden Purbeck, and the Lower Cretaceous rocks) which is in Ireland without a single record. All the evidence, also, would seem to point to the fact, that this absence of the rocks is due to an original absence of deposition, and not to any subsequent denudation; and would, therefore, indicate that for the vast lapse of ages, represented by all the rocks between the Carboniferous period and the commencement of the post-Tertiary, the greater part of Ireland was elevated into dry land, while the sea covered widely the whole central portion of England. The little tabular view (given on p. 3) of the different formations on both sides of the Channel, showing which are present and which are absent, will be found very useful.

Briefly referring to the Cambrian rocks, so well known to visitors of Dublin, from their readily accessible positions at Bray Head and Howth, to the south and north of Dublin Bay, the author proceeds to the Lower Silurian beds, which rest unconformably on these older rocks, the gap between the two representing the absence in Ireland of the *Lingula Flags*, or Upper Cambrian of North Wales (English Survey classification). These Lower Silurian deposits are among the most interesting to the student of Irish geology, from the fact that they occur in two very distinct phases, now perfectly established as representative one of the other. In the one they are still unaltered, and still full of fossils, though indurated, contorted, and disturbed; in the other they have become highly crystalline, metamorphic schists, gneiss, hornblende schists, etc. The age of these rocks is well fixed both by position and by fossils, as belonging to the great Lower Silurian, and being probably about that of the Caradoc and Llandeilo groups. Beds of limestone occur, though rarely, and contain fossils representative of the Bala beds. These rocks, in their metamorphic condition, occupy four areas in the north and north-west of Ireland. 1. West Galway and part of Mayo. 2. North of Clew Bay. 3. The Ox Mountains from Lough Cong to Lough Gill. 4. Donegal and Derry. To the east of the island there is a north-eastern area in the highlands flanking the Mourne Mountains, and north of Dundalk, and a south-eastern extending from near Dublin to the coast of the county of Waterford.

There are only two areas of any great extent of Upper Silurian rocks in Ireland —one near the Killaries, in Galway, between Lough Mask and the Atlantic. And this is of high interest, as affording undoubted evidence of the date of the metamorphism of the rocks which we have just noticed—evidence which the country of Scotland, so rich in metamorphic phenomena, has not yet afforded. There the rocks immediately resting on the metamorphic Lower Silurian beds are the Old Red Sandstone, and it is therefore only possible to assert that the metamorphism took place prior to the formation of the Old Red Sandstone. But here—in Galway—resting on metamorphosed rocks of unquestionably the same general age as those of Scotland, we have, quite unconformably, masses of conglomerates, grits, shales, etc., formed out of the debris and waste of these metamorphic rocks, and which themselves, though containing beds of volcanic ash, and sheets of felspathic lava, —evidence of contemporaneous volcanic action during their deposition,—still exhibit no trace of that wide-spread and deep-seated metamorphic action so strongly developed in the lower beds. These beds in Galway probably represent the Wenlock and Ludlow beds of England. The only other important locality is near Dingle, where a very large series, probably representative of the whole Upper Silurian series of England, occur. These have derived some special interest from the occurrence above them, and conformable to them, of the series to which Jukes gave the name of 'Dingle beds,' a great thickness of grits, shales, and conglomerates, which are themselves unconformably covered by the lowest beds of the Old Red Sandstone.

The absence in Ireland of any marked representative of the true Devonian, or marine equivalent of the Old Red Sandstone, is noted, and the distinctively Irish characters of the Old Red as a formation insisted on. This vast thickness of sandstones, conglomerates, and slates appears to have been thrown down in the waters of a large lake or great inland sea, as first pointed out by one to whom English geology is largely indebted for broad philosophical speculation in its physical history, Mr. Godwin-Austen (not Austin as printed), or rather in two lakes separated by a great ridge of Silurian land crossing Ireland, and what is now the Irish Channel, into North Wales and Central England, though in all probability the basin formed to the south of this ridge did not extend so far in the south-east. In the northern area the rocks have much the same character as their representatives south of the Grampians and in Central Scotland; but in the south and south-west the formation shows two distinct members—the upper of which (essentially Irish) very distinctly passes into the Carboniferous rocks above, the lower forms the greater portion of the extensive counties of Cork and Kerry, and forms some of the most elevated ground in Ireland.

About one-half of the entire area of Ireland is occupied by rocks of the Carboniferous series, chiefly confined to the lowermost members, the Carboniferous slate and the Carboniferous limestone. This latter, which was with justice called the Mountain limestone in England, ought more properly in the sister-isle to be called the Plains limestone, because, excepting in parts of Leitrim, Sligo, and Fermanagh, where it rises into bold isolated hills and escarpments, it is found only under the wide-spreading plains of the country. The Upper Carboniferous beds, including some of the Coal-measures, are now only represented in a few detached areas, barely sufficient to mark the former widely-extended area of the formation. The Carboniferous Limestone itself presents in Ireland three acknowledged divisions. (1) The Lower Limestone, generally a pure, fossiliferous limestone, many of the beds yielding richly-coloured and handsome marble; (2) the Calp, a dark-coloured earthy and shaly series; and (3) the Upper Limestone, often of a lighter grey colour than the lower, and often full of "Chert," both in irregular layers and masses like the flints in chalk. Volcanic rocks occur in places, showing the existence of such action during the deposition of these rocks. Representatives of the "Yoredale beds," and of the "Millstone-grit" of England also occur; as well as of the "Gannister beds." Of the Upper Coal-measures, whatever may have been their original extent, there now remain only two or three very limited areas, as at Castlecomer in the counties of Carlow and Kilkenny, and Killenaule in Tipperary (which may be considered parts of the same general area): and at Coal Island in Tyrone.

Permian rocks have only been recognized in a few places; the Lower Permian only in one; viz. a few feet of conglomerate and breccia resting on the Lower Carboniferous Limestones of Armagh. The Magnesian Limestone is represented, though poorly, near Cookstown in Tyrone, and at Cultra, on the south shore of Belfast Lough.

Of the Mesozoic rocks, as already stated, no representatives are known in any part of Ireland, excepting in the north-east; there the Triassic rocks form a narrow band, encircling the basaltic region of Antrim and East Derry, generally occurring in the lower ground of river valleys. The two groups of the Bunter Sandstone and Keuper are both recognizable, the former chiefly in Belfast Lough and near Dungannon, etc., and the latter between Larne and Carrickfergus, marked by the presence of bands of gypsum and extensive beds of rock-salt (Carrickfergus). At Scrabo, near Newtownards, the Triassic sandstones are capped by masses of dolerite, and are also penetrated by horizontal sheets, and vertical dykes of basalt, intersecting each other in various directions, and affording a magnificent opportunity for the study of such phenomena.

The Lower Liassic and Rhætic beds occur together in a few places round the north-east coast, as at Colin Glen, near Belfast, Larne, and Portrush; at the latter locality indurated and converted into a kind of Lydian stone, by contact with a sheet of intrusive dolerite. At Larne the beds are of light blue and deep grey clays, with earthy limestone, containing *Gryphæa incurva*, etc., and below these dark shales with *Avicula contorta*.

There are no representatives of the main portion of the Lias of England, nor of any of the numerous divisions of the Jurassic rocks, as yet known in Ireland. They very probably were never deposited; but if they were, they had been entirely removed again before the period of the formation of the Upper Cretaceous rocks. For there is no representative of the lower part of this great series either; we find only the Upper Greensand and the Chalk with flints. The whole group varies in thickness, but never exceeds a maximum of about 350 feet. The upper surface has been largely eroded, and an irregular bed of flint-gravel, with red ochre filling up the hollows in the rocks, generally occurs between the chalk and the sheets of volcanic lava by which it is covered. There has not been much contortion or disturbance of the beds, which are, for the most part, nearly horizontal, but as a whole they form a shallow basin-shaped area (the central depression of which is marked approximately by the course of the River Bann), dipping towards this depression from the sides. We do not see that our author notices the fact, which is certain to be among the first to strike the stranger, that the Chalk of Ireland is a hard, compact, white limestone, without any of the soft granular and powdery character distinctive of the English Chalk.

The occurrence of the Cretaceous formation in this isolated locality, so far from the nearest north-west point of its area in England, is of much interest, as bearing on the question of its former greater extension. Prof. Judd has also found Cretaceous rocks in the Isle of Mull, far away to the north, and the sharply truncated edge of the formation along its western and eastern faces in Ireland would seem to establish that it formerly covered a considerably larger area. It is not improbable that it was even connected with the English area at the time of its deposition; and if so, it would appear probable, further, that this connexion occurred over the lower country or depression which now separates the mountains of Wales from those of Cumberland and North Lancashire. To the west, it was probably limited by the highlands of Donegal and Sligo.

The old volcanic rocks of Antrim, long classical ground to the geologist, which cover nearly all the area in that county, as well as considerable portions of Londonderry and Tyrone, forming generally a very well marked and elevated plateau, succeed to the Cretaceous beds just noticed. Prof. Hull (Brit. Asso. 1874) had already pointed out that these were capable of a three-fold division: the earliest stage marked by trachyte porphyry (Sandy Bræs, Temple Patrick, Hillsborough). The masses are very limited in extent as compared with the succeeding overflows. The rare mineral Tridymite has been found in the cavities of these rocks. The actual age of these outbursts is unknown, but Prof. Hull thinks they probably belong to the later part of the Eocene period. They are thus possibly the only Eocene rocks in Ireland. The middle stage of the volcanic rocks is characterized by vesicular amygdaloids, and basalts, often separated by beds of red bole, and succeeded by volcanic ashes and larger bombs of trap. These are supposed to have been subaerial discharges of volcanic matter, the intensity of the volcanic action being succeeded by a period of repose, during which peculiar beds of pisolitic iron ore, and layers of fine *débris* of the rocks, containing plant-remains, were deposited, probably in lacustrine waters. These plants have proved similar to those found in the Isle of Mull, and have thus been taken to indicate a similar Miocene age. And then, finally, after this period of repose, the volcanic forces again became very active, and gave forth vast flows of lava, now successive beds of columnar basalt, which are often seen resting directly on the thin beds of iron ore, or on a bed of lignite.

The total thickness of these volcanic rocks is often more than 1000 feet: all actual craters and cones have long disappeared by denudation, but 'necks' are still to be traced through which some of the volcanic outbursts were forced up. These have been noticed by other observers, but our author brings forward as an instance, a locality visited yearly by hundreds of tourists, namely the now detached and ruined Castle of Dunluce between Portrush and the Giant's Causeway—which he states is built on a mass of agglomerate, originally forming one of these 'necks.' In a subsequent page, however (p. 70), he says his views on this point have been recently altered during a visit to the localities along with Prof. Ramsay and Mr. Traill, and that he is now disposed to view these cases as simply pipes formed by filtration out of the chalk, into which the basaltic masses have fallen or slipped down, thus giving rise to their fragmental appearance.[1]

[1] Those who are curious to trace out accurately the successive steps by which opinions are formed, put forward and obtain currency, in such matters, will be amused to follow up this case of supposed 'necks' in the basaltic country of Antrim. Let them look first then to Portlock's Report on Londonderry, etc., 1843—more than thirty years since, and at p. 92 they will find a carefully drawn view of one of the instances referred to by Prof. Hull, and an equally carefully drawn up description of the appearances presented by the rocks. Portlock says: "The trap penetrates into the chalk, and forms a conglomerate with the flints and fragments of chalk it

After a brief notice of the frequent occurrence of basaltic dykes in the country adjoining these volcanic rocks, the author proceeds to the only known Pliocene beds in Ireland. These occur as quietly deposited beds of clays, filling in a part of the older extent of Lough Neagh. They now extend 80 to 90 feet above the level of the lake, and have been pierced to a depth of 300 feet, the maximum thickness being nearly 500 feet. They rest on an eroded surface of the Miocene basalt, from which they are separated by a bed of rude conglomerate formed by masses of these basaltic rocks. They are generally stiff and plastic bluish clays, much used for coarse pottery, etc. In them remains of what is described as an *Unio*[1] have been found, and also of plants—the whole character of the beds indicating a quiet deposition under tranquil waters in an equable if not a warm climate. They were the old lacustrine delta deposits of the Upper Bann and other streams entering Lough Neagh from the south. The Pliocene period is but sparingly represented in any part of the British Islands, and these deposits become of even greater interest from the absence of any contemporaries. Of the Pliocene period in Ireland, Prof. Hull says, "Ere it set in, the volanic fires had smouldered away. It was an age of calm repose, separating the period of volcanic activity on the one side from that of frost and ice on the other; and during its continuance the ordinary agents of denudation—rain, rivers, and sea waves—carried on their operations without unusual interruption, but with marked effect in modifying the physical features of the north and adjoining districts of Ireland." (p. 76.)

This brings us to the close of the Tertiary period. There still remains, however, a long series of deposits to be noticed, which in reality cover more than three-fourths of the whole area of the country, and to the presence or absence of which a very large amount of the varying characters of its scenery is due. Important, however, as they are, we cannot afford space for more than the briefest notice of these "Post-Pliocene or Drift-deposits," as Prof. Hull classifies them,—the Glacial and post-Glacial clays, sands, gravels, etc., and the still more recent deposits, forming raised

has in its progress enveloped. Many, but not all, the flints are changed to red, and the chalk fragments are comparatively few, the lime having, it is probable, contributed to form the enveloping paste, which is in part rotten and soapy. Some of the immersed fragments of chalk are powdery to the touch, though still retaining a definite form, and such is also the case with the flints. The great body of the trap is here concretionary; and as the softer portions wear away, the harder projecting lumps look like huge boulders in a rude conglomerate. The bottom portion is obscured by rubbish, so that it is impossible to say whether the trap has risen through the gap, as through a crater, or has been poured into it from above, but on the east side the chalk in a considerable mass rests upon trap, and is at the same time overlaid by it." Now let him turn to Jukes's Manual of Geology, edited by A. Geikie, 3rd edit., 1872, and at p. 271 he will find a figure (fig. 107) intended to represent the facts seen at the same locality exactly—from a sketch made by Prof. Geikie himself. After noticing where this assumed 'neck' occurs, he says: "A cavity, measuring about fifty yards across at the top, has been blown through the chalk, and also through a previously erupted sheet of basalt, and this cavity, after, perhaps, serving as an orifice for the discharge of some of the tuffs of the district, was finally filled up with a coarse mass of rubbish, consisting of blocks of basalt, chalk, etc., imbedded in a dirty green gritty trappean paste." The writer thinks it evidently quite beneath his consideration to think of giving any proofs of these boldly-asserted views—or to offer the slightest explanation of how his 'gritty trappean paste' was formed, or when. Then as the last step in the history of this curious case, we have Prof. Hull (p. 56) saying: "The old necks are choked up by bombs which have been blown into the air, and in falling back have filled up the throat," referring to this very case, near Portrush, and then (on p. 70) he withdraws from this view, and holds these cases to be old pipes in the chalk, "into which the basaltic masses have fallen or slipped down," that is, we presume, after they had been to a considerable extent at least, if not entirely, cooled and hardened. Has he any proof of this? If so, why is it not noticed? After the student has traced the successive steps in the history of this sketch, and seen the several additions in the story, which each of its narrators have added—additions for which they were indebted purely to their own poetic imaginations—we cannot help thinking that, so far as any real truth, objective truth, is concerned, he will return to the description of thirty years since, where he finds the limits of knowledge and ignorance clearly noted and candidly avowed, in preference to the apparently more finished, perhaps, but less thorougly established dogmas of recent observers.

[1] See Geol. Mag. Dec. 1876, p. 557.

beaches, river terraces, etc., which are so numerous and widely spread. The author still adopts the same classification as he formerly did, of these representatives of "The Great Ice Age," and makes three groups. (1) The Lower Boulder-clay or Till; (2) Middle Sands and gravels, the Limestone gravels of Ireland; and (3) the Upper Boulder-clay, and notices in some detail the peculiar circumstances under which each of these occur. It will be sufficient here to indicate the conclusions, that the earlier period indicates a time when the surface of the country was more elevated than now, but was somewhat in the same condition as the north of Greenland, etc., is at present, that is, was covered with a continuous ice-sheet of great thickness, and in continued motion in given directions. Secondly, a period of comparative depression, amounting probably to 1500 feet, accompanied by an amelioration of climate, and an overspreading of the land by the ocean, when water-arranged deposits of sands, gravels, etc. (often containing shells), were formed; and thirdly, a period of gradual elevation, when glaciers again accumulated in local centres around the higher grounds which produced the true glacier moraines, still so frequent in the highlands of the country, and from which drifting icebergs probably conveyed, and dropped at intervals over the country, the boulders which are now found resting on the Middle Sands in many places. It is, however, but right to notice the fact that this classification, although adopted by many, and now before geologists for many years, has by no means commanded universal acceptation. There are still many who hold that the subdivisions noticed are merely local, and by no means so general as to afford sufficient data for the large and wide generalizations which have been based on them. Our author does not himself accept some of the views of other glacialists. We find in his pages no evidence of a belief in the second outspreading or return of a great ice-sheet, after the formation of the Middle Sands, although this is the view of others, and he has been careful to explain fully the much more limited extent, and frequent total absence of the Upper Boulder-clay. The Lower Boulder-clay is by far the most widely distributed of the three groups, occurring in greatest mass in the lower grounds and deeper valleys. Most of these valleys have, in fact, been re-excavated out of it, detached patches of it being left on the side slopes. But even this lower division is not universally present, and even in the lower grounds there are instances where considerable areas are entirely free from it, while closely adjoining areas are thickly covered. The Upper Boulder-clay, on the contrary, is much more sparingly distributed, and in many parts of the country it has never been deposited. It further often shows distinct signs of arrangement in layers or strata, and has therefore been formed or rearranged by water, while the gravels and sands, on which it is said to rest, give evidence of erosion by water action, but do not appear to have been fairly ground down, or displaced by a mass of ice. The upper limits of this deposit appear to be less than 1000 feet above the present sea-level.

Then we have a series of terraces in the highlands which are attributed to successive formation along shores as the land was emerging from its depression during the Middle Glacial period, at a time when the land was gaining on the sea, and when pauses in the upward movement took place. The "Eskers" are noticed as "the results of tidal and other currents acting on the soft materials of the drift, as they oscillated within narrow channels, bounded by the ridges of the unsubmerged land, piling them up along tortuous lines in the form of embankments" (p. 99). Mr. Kinahan's distinctions of *Bar-eskers* and *Shoal-eskers* are alluded to. There is then a full notice of Local Moraines, or true Glacier Moraines, both lateral and terminal, and numerous instances given both from the Wicklow and the Galway Mountains. We then pass to Raised Beaches and River Terraces; and the evidences of the successive steps in the elevation of the land to its present level are brought down to the "15 foot beach," which is traced along the coast from the north to Dublin, where it is shown probably to merge into the old estuary terrace of the river Liffey, on the flat surface of which some of the principal parts of the capital of Ireland are built (Custom House, Post-office, Sackville Street, Bank of Ireland, University, etc.). In this terrace, with the shells have been found flint implements, establishing the fact that it has been formed since the occupation of the country by its early inhabitants. This, therefore, connects the Geological with the more purely Archæological portion of the history. A capital little sketch geological map, coloured by hand, forms the frontispiece to the book, and to those who have not at hand any larger or more detailed map, it will give a fair clue to the general distribution of the various rocks.

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

III.—Geological Map of Scotland. By Archibald Geikie, LL.D., F.R.S., Director of the Geological Survey of Scotland, Murchison Professor of Geology in the University of Edinburgh. (W. and A. K. Johnston and Co.: Edinburgh, 1876.)

OF late years the work performed by the Official Geological Surveys has made an immense addition to our knowledge of the characters and inter-relationships of the rock-formations of Britain. This addition, however, has been almost wholly confined to two departments of Geological Science. While Stratigraphical and Mineralogical Geology have advanced with gigantic strides, Stratigraphical Palæontology has remained almost at a standstill. Originally occupying the proud position of friend and mentor to Zoology and Geology alike, extending a helping hand to either, Palæontology now-a-days seems to bestow all her favours upon the former. The philosophical zoologist has gradually been forced to recognize the inestimable value of her counsel, and to expect from her alone the solution of some of his most perplexing problems of life and its distribution. The practical geologist has simultaneously been losing faith in her monitions, and at present openly cherishes the belief that the day is at hand when he can safely dispense with her reluctantly accepted assistance altogether. Conscious of his great inferiority to the practical geologist in the amount and reliability of his data, and disconcerted by the hazy doctrines of representative forms, homotaxis, colonies, migrations and the like, the palæontologist in general is compelled to speak with a diffidence that has inevitably led to the almost total neglect of his opinion on geological classification. The pure stratigraphist, on the other hand, certain of his facts, accepts only such of the conclusions of his palæontological brother as may happen to coincide with his own, and makes his arrangements on mineralogical and stratigraphical data alone, in the confident assurance that "the domination of Palæontology is gone for ever."

Perhaps no more vivid illustrations of this tendency can be seen than in the beautiful map before us. Here, in one area, two formations, hitherto held by geologist and palæontologist alike to be totally distinct, are considered as one, simply on the grounds that they agree locally in physical conformity and in mineralogical similarity; although elsewhere they are separated by thousands of feet of intercalated strata. In another district the apparent stratigraphical evidences are so consistent that they are held to be demonstrative of the co-existence in Scotland of distinct groups of marine animals, which in other countries are strictly confined to wholly different formations.

The microscope of research has so magnified the geological field that each formation has practically become a system,—crowded with detail, and demanding a multiplicity of attainments, and a lifetime of application for its proper investigation. Thus, day by day, the average geologist becomes more and more of a specialist; possessing, it may be, a knowledge, more or less perfect, of that minor section of his great subject which the accidents of training and locality have made familiar and attractive to him, but forced to found his ideas respecting the rest of the geological world upon the data furnished by the discoveries and speculations of others. Scattered as these are in the maps and memoirs of the Survey, and in the pages of multifarious and often inaccessible scientific publications, he cannot be sufficiently grateful to those who have the opportunity and patience to reduce this mass of heterogeneous material to order, and bring a summary of the more important results before his eyes at a single glance in a general geological map like the present.

We know of no other map of this class in which this task has been so perfectly and so conscientiously performed. Prof. Geikie, in his official capacity as head of the Scotch Survey, enjoys exceptional advantages in the command of numberless geological details as yet unpublished, and in his perfect familiarity with the ground mapped by himself and his subordinates. But he also brings other and far more vital qualifications to the execution of his task. No one has personally added more to our knowledge of the physical structure of Scotland, or has thought more profoundly over the many unsolved problems of its geology. There are few districts in the country to which his eloquent writings have not imparted a new interest; and there is scarcely a single formation in its geological series in which he has not added to our previous knowledge by discovery or original observation. To him also is mainly due that excellent little map of Scotland published by Johnston in 1862, in which the so-called Laurentian, Cambrian, and Silurian rocks of the Highlands were laid down, and the first successful attempt was made to delineate with correctness the distribution and mutual relationships of the Scottish deposits in general.

In the compilation of his facts the author has not only availed himself of the vast mass of new details worked out by himself and the officers of the Geological Survey, who have now practically finished the mapping of that portion of Scotland lying to the south of the metamorphic rocks of the Highlands, but he has profited to the full by the facts detected in other areas by Harkness, Jamieson, Judd and others. The topography of the map is by Mr. T. B. Johnston, and is perfect in its way. By the omission of all hill-shading, and by the use of skeleton-letters for the names of the chief natural features, etc., much of the ground of the map is left bare, and room is thus gained for the insertion of a large amount of geological detail.

The system of colouring adopted is that which has long been in use in the publications issued by the Geological Survey of Britain —the different shades of red being employed almost exclusively to mark the various classes of igneous rock. This plan is so simple and convenient in application, and so valuable as a distinct aid to the memory, that it should be employed invariably upon all maps, where several different formations are represented. One other feature of this map cannot be too strongly commended. With one or two minor exceptions—and these perhaps unavoidable—all the tints are quiet in tone. We have none of those painful contrasts of faint and almost invisible washes placed side by side with glaring splashes of brilliant paint, which disfigure even some of the best of the Survey maps. Here, while the brighter colours mark at a glance the localities of the igneous interruptions to the general continuity of the more soberly tinted aqueous deposits, the general tone of the map is quiet and subdued. Not a single detail is obscured, and the general effect is grateful and pleasing to the eye.

In indicating the main points of advance made by the present map upon its predecessors, we shall pass over the earlier geological maps of M'Culloch and Nicol, and restrict our observations to a comparison with the small map of Murchison and Geikie already referred to, and which was professedly the first sketch for the geological map of which the present publication is the completed design.

Beyond the more exact delineation of the boundaries of the Lewisian gneiss and the Torridon sandstones, we are presented with nothing new in the fundamental rocks of Sutherland and Ross. The larger scale of the map, however, not only admits of the more precise definition of the limits of the various divisions of the Highland metamorphic rocks, but a vast amount of new detail is inserted. In the all-important area of the North-west Highlands the great Durine band of quartz-rock is seen to be by no means so broad or so invariable a geographical feature in that district as appeared from the earlier map, nor do its two limestones always appear to occupy the same relative places in the general series.

The quartz-rocks which imbed the classic limestones of Glen Tilt are no longer figured as forming a vast elliptical island in the metamorphic schists, but are seen to be extended far to the north in the wilds of Badenoch, and to form four narrow strips running through Banff and Aberdeen to the shores of the German Ocean. On the other hand, although the line of anticlinal axis, running from Loch Tay to the mouth of Loch Fyne, is distinctly laid down, the great sheet of supposed quartz-rocks which formerly accompanied it, and was believed to be prolonged to the Mull of Cantire, is now coloured as of later age, and the limestones which partially defined its upper boundaries are now theoretically placed at the summit of the succeeding schistose formation, instead of at its base.

The clay-slate formation of the older geologists again finds its special place and colour upon the map, and we recognize with something akin to pleasure our old and well-nigh forgotten acquaintance, in its original position along the southern margin of the Highlands. Its geologic place, however, appears to be to the full as difficult of definition as ever. If we may trust the Argyllshire sections and the legend on the map, it must be separated from the basal quartz-rock formation by an enormous series of micaceous schists. If the Banffshire sections are to guide us, it must repose at once upon the quartz-rock formation, without the intervention of any schistose beds whatever.

Turning next to the unaltered deposits of the Southern Uplands, we notice that the Upper Silurian colouring has been very properly extended to the schists and flagstones of Langholm and Stobo, which lie to the south of the Hawick rocks, and agree in every respect with the Coniston Flags and Grits of the North of England. Although the officers of the Survey have satisfied themselves of the existence of several important divisions in the so-called Llandeilo series of greywackes whose contorted beds floor almost the whole of the Uplands, no attempt has been made to define their limits upon the small scale of this map. A new and most valuable feature is seen, however, in the insertion of the main lines of black shale in the central districts and Galloway, but no distinction is made between the so-called Upper and Lower groups. These omissions are compensated to a certain extent by a marginal section through the central portion of the Silurians from the Cheviots to Tinto. Here the Ardwell or Hawick rocks are figured as being covered unconformably to the south by the Riccarton Beds of the Upper Silurian, but the hypothetical nature of the break is carefully indicated by a note of interrogation. The thin deposit of the Moffat Shales is shown as reposing upon the Ardwell Beds and passing below the Queensberry Grits to the south of Ettrick Pen, and on both slopes of the Moffat Valley. It is a little awkward for this theory that there are no black shales in this position to the south of Ettrick Pen, nor for many miles to the north-east; while the extension of this strike to the south-east would carry us deep into typical Ardwell Beds. At the same time the black bands on the opposite side of the Moffat Valley happen to be the most easily demonstrated anticlinal forms in the whole of the Moffat district.

The numerous patches of calcareous grit and conglomerate with Caradoc and Llandovery fossils are shown by a distinct colour upon the map. In addition to the typical area of Duntercleuch, the corresponding strata of Kilbucho, Wrae Hill, Moniave, etc., are marked as of Caradoc age. In the section they are represented as unconformable upon the Llandeilo greywackes. This classification has been extended to the interesting Girvan area. The great fault formerly supposed to cut off the Llandeilos of the Uplands from the Girvan beds is omitted, and the Caradoc tint is restricted to the two small and possibly unconformable patches of Assel and Craighead.

A special and highly interesting feature of this map is the development and classification of the rocks which lie between the summit of the true Upper Silurian and the acknowledged base of the Scottish Carboniferous Limestone. The long line of fault throwing down the Red Sandstone of Strathmore from Stonehaven to Loch Lomond is here, for the first time, shown in its true position; and the irregular boundary of the basal conglomerate upon the clay-slates of the southern margin of the Highlands is carefully shown from the work of Professor Geikie and his assistants. The more important results of the recent work of the officers of the Survey in Forfar and Kincardine are filled in. Special care has been bestowed upon the strangely interlaced group of felstones, ashes, and sandstones of the Sidlaws, Ochils and Pentlands, every conspicuous rock-sheet being laid down with painful minuteness.

In accordance with the views broached by Professor Geikie in 1876 the so-called Lower and Middle Old Red Sandstones south of the Grampians are regarded as constituting a single formation; the unconformity visible between Tinto and the Pentlands being looked upon as a local feature dependent upon the igneous action so rife at that period. In the face of the evidences he has adduced, it is impossible to resist the conviction that this arrangement, so far as these beds are concerned, is the one which is most convenient and most in accordance with the order of nature; and in these respects it must be looked upon as a decided gain. His second conclusion, namely, that the Caithness Flagstones are, in all probability, of contemporaneous age with the admitted Lower Old Red Sandstones of Perth and Lanark, is of too sweeping a nature to be so readily conceded. The author seems fully aware of this fact; for though the beds are coloured as of Lower Old Red age upon the map, the original lettering, expressive of their Middle Old Red age, is still retained.

His third and most important conclusion, that everywhere throughout Scotland the so-called Upper Old Red Sandstone reposes with a violent unconformability upon all the underlying rocks, and shades upwards into the basal beds of the Carboniferous, is made to do great service. This subformation is here coloured as if of Old Red Sandstone age, but is bracketed with the Carboniferous. The detection of marine fossils characteristic of the Carboniferous Limestone in red beds far inferior in geologic position to the theoretical base of the Cement-Stone group, or Upper Calciferous Series, of Arran, is very naturally regarded as of immense weight, and is held as sufficient in itself to demonstrate the co-existence of the typical Upper Old Red Sandstone fauna with that of the Carboniferous Limestone. The red or lower division of the Calciferous Sandstone Series is therefore no longer united to the upper or grey division, but is grouped with the underlying and lithologically similar formation of the Upper Old Red Sandstone.

This change we believe to be wholly uncalled for, especially in the present stage of the Devonian controversy, when every step should be made with the greatest circumspection. All who have interested themselves in this question are well aware that in the south-west of Ireland, the Upper Old Red Sandstones are separated from the lowest Carboniferous Limestones by the enormous mass of the Coomhoola Series and the Lower Limestone Shales. These rapidly thin out as we proceed to the north, until the Carboniferous Limestone rests at once upon Silurian rocks. Still further to the north the Limestone itself is divided into an upper and lower portion by the intercalation of the sandstone beds of the Calp. Almost upon the same parallel the interesting researches of Mr. Goodchild have made it evident that the Carboniferous Limestone of Westmorland is similarly divided into an Upper and Lower portion by the gradual intercalation of the Ash Fell Sandstones, etc., with a few calcareous bands. The arenaceous rocks thicken out as we pass northward to Cross Fell, while the underlying lower portion of the Carboniferous Limestone simultaneously thins away till the arenaceous rocks rest immediately upon the Silurians. The Scottish Calciferous Sandstones are admitted to be actually the northerly extension and expansion of these red and grey sandstones of Westmorland. In other words, they are simply arenaceous representatives of the Lower or central portion of the English Carboniferous Limestone. The greater abundance of these coloured sandstones in the Carboniferous rocks of Arran is in exact correspondence with the general behaviour of the strata of this system in Britain generally; and the presence of the Carboniferous Limestone fossils, even in their very lowest beds, instead of being matter for astonishment, and an argument for a local revolution in our present plan of classification, is, on the other hand, so natural and inevitable under our present ideas of the relationships of the Upper Old Red and the Carboniferous, that, from an *à priori* point of view, it is almost impossible to conceive how the facts should have been otherwise.

Of the Carboniferous formation itself, four divisions are noted by the author—the Calciferous Sandstones, the Carboniferous Limestone, the Millstone Grit, and the Coal-measures. The first of these, under the arrangement already described, includes only the Upper or Cement-stone division of the original Calciferous rocks. The limits of these sub-groups are accurately traced through the whole of the Central Valley. The disputed coal-field of Canobie is fixed as belonging to the true Coal-measures, and the wide sheet of Carboniferous rocks in Eskdale, etc., has been removed to the Calciferous Sandstones.

The Permian areas of Annan, Dumfries, Thornhill and Moffat, have now for the first time their limits correctly laid down. No alteration is made in the outline of the Triassic district in the neighbourhood of Elgin; but the small patch of rocks of this age discovered by Professor Judd near Dunrobin is indicated upon the map, and the complete dissipation of the doubts regarding the actual presence of this formation in Scotland is distinctly acknowledged in the removal of the note of interrogation from its title in the margin.

Indeed, the masterly papers of Professor Judd have proved a mine of wealth to the author. As far as possible all the more important details worked out by him are here inserted. The Jurassics of Sutherland and the Western Isles are coloured in two divisions; the Cretaceous rocks find for the first time in the map of Scotland their special place and colour; and the geological structure of the volcanic region of Mull and the adjacent coasts is delineated with a minuteness and clearness, which, when we consider the small scale of the map, is almost marvellous.

Glacial and post-Tertiary geology generally comes in for a full share of attention. Over the whole country are arrows showing the local direction of the glacial striæ. The main streams of glacial debris and morainic matter are dotted in over the Lowlands, and upon both flanks of the Grampian range. The raised beach, the fertile carse of alluvium and the barren tract of blown sand, are separately indicated, each by its special and appropriate shade of colour.

In point of execution and finish the marginal sections are decidedly inferior to the main body of the map. They are six in number, and illustrate the geological structure of the Highlands, Forfar, the Southern Uplands, the Midland Valley, and the Volcanic Region of Mull and Morven.

The igneous rocks have been laid down with special care. They are distinguished by a separate type of colour according as they belong either to the acidic or pyroxenic and basic series; the main species of each group being separated by variations in depth of tint. Much advance has also been made in their chronological arrangement. The main geographical masses, whose age has been satisfactorily determined, are marked upon the map by the letter or figure significant of the epoch to which they belong. The outlines of the chief granitic areas of the Uplands and Highlands are corrected; but although the author has elsewhere shown that there is a high probability that they are of Old Red age, he has wisely refrained from fixing their systematic position upon the map. The ring of igneous rock which surrounds the great Valley of Central Scotland is now lettered as being composed of two portions of very different ages. The Pentlands and Ochils belong to the Old Red Sandstone, while the Campsie Fells and the hills of Renfrew and Cunningham are classed with the Lower Carboniferous. The Cheviot porphyries are correctly mapped for the first time, and are definitely assigned to the earlier of these epochs. The main sheets of igneous rock among the Upper Old Red beds of Roxburgh are inserted, and the peculiar amygdaloidal trap which lies at the base of the Carboniferous Sandstones of Riccarton, is traced continuously from the northern flanks of the Cheviots into the well-known igneous mass of Barnswark in Annandale.

Of the thorough correctness of the geological portion of the map we can speak with perfect confidence, as it has been our faithful companion in many a geological excursion, not only in the well-known beds of the Central valley, but also among the more enigmatical strata of the Uplands and Highlands, and we have invariably found it correct.

In the multiplicity of its detail, in the conscientious accuracy of its workmanship, and in its fitness for the special purpose it is intended to subserve, this map is unique in its class. It is creditable alike to its author and to its publisher, and is simply invaluable to those who wish to possess an accurate knowledge of the geological structure of Scotland. C. Lapworth.

## REPORTS AND PROCEEDINGS.

The Geologists' Association.—At a meeting held at University College on the 4th January last, Mr. H. Goss, F.L.S., F.G.S., etc., communicated a paper on "The Insect Fauna of the Secondary or Mesozoic Period, and the British and Foreign Strata in which Insect-remains have been detected." After making some introductory observations and calling attention to the writings and investigations in the United Kingdom of Dr. Henry Woodward, F.R.S., the Rev. P. B. Brodie, Prof. Westwood, the Rev. Osmond Fisher, and others, Mr. Goss observed that the majority of the fossil insects from British strata of the *Secondary* period had been obtained from the Upper Oolite (Purbecks) and from the Lias, and that nearly all the European specimens had been discovered in the Solenhofen slate of Bavaria, or in the Lias of the Swiss Alps. Allusion was made to the difference in the state of preservation of insects from British strata of this period as compared with that of those from the Solenhofen slate, and the probable reasons for this difference in the state of preservation were stated. The names of the principal discoverers and students of fossil insects from Secondary rocks on the Continent of Europe, including those of Professor Germar, Count Münster, Dr. Hagen, Professor Heer, Dr. Giebel, etc., were then mentioned, and Mr. S. H. Scudder was referred to as the chief worker in America.

The various strata of this period, both in the United Kingdom and on the Continents of Europe and America, in which fossil insects had been detected, were then enumerated in the descending order of geological succession.

It appeared that a few insect-remains had been obtained from the Weald Clay and Hastings Sands, and a great number from the Purbeck strata of Dorsetshire, Wiltshire, and Buckinghamshire, especially from those of the first-named county. The species which had been identified belonged to the orders *Coleoptera, Orthoptera, Neuroptera, Hemiptera, Diptera* and *Hymenoptera*, and more than half of those from the Dorset Purbecks belonged to the first-named order. The Purbeck species appear as a rule to be closely allied to existing forms, and the small size of the majority of them was, in the opinion of Professor Westwood, indicative of a temperate climate; but from the nature of the remains of other orders of animals, and of the plants from these strata, the prevalence of such a climate during this period seemed improbable.

A few Elytra of *Coleoptera* were recorded from the Kimmeridge Clay, the Forest Marble and the Great Oolite, and the remains of one insect, which Professor Westwood thought might be referred to a larva of *Libellula*, had been found in the Oxford Clay. The remains from the Stonesfield slate were principally Elytra of *Coleoptera*, but they also included a few *Neuroptera* and two doubtful specimens of *Lepidoptera*. One of the supposed *Lepidoptera* (which had been described and figured by Mr. A. G. Butler, and named by him *Palæontina Oolitica*) was considered by Mr. Scudder to be *Homopterous* rather than *Lepidopterous*, and allied to *Cicada*.

A great quantity of insect-remains had been obtained from the Lias and Rhætics, but they were generally in such a fragmentary condition that the bulk of them could not be identified. About 56 species had been determined, and they had been referred by Westwood and Brodie to the orders *Coleoptera* (29 species), *Neuroptera* (12 species), *Orthoptera* (7 species), *Hemiptera* (6 species), and *Diptera* (2 species); but no traces of *Hymenoptera* or *Lepidoptera* had been met with, and the remains referred to the *Diptera* were very doubtful.

The Lias insects, although apparently belonging from their size to a temperate climate, differed from those from Purbeck strata in being less closely allied to European forms, and approaching nearer to those now inhabiting North America.

On the Continent of Europe a few remains of insects, which had been referred to *Carabidæ* and *Curculionidæ*, had been obtained from the Cretaceous strata in the neighbourhood of Aix-la-Chapelle, and a few traces of insects had also been noticed by Dr. Geinitz in the Greensands of Saxony.

Attention was then drawn to the remains from the Solenhofen slate, which had been referred by Germar, Münster, Hagen and Giebel to insects belonging to the orders *Coleoptera*, *Orthoptera*, *Neuroptera*, *Hymenoptera*, *Hemiptera*, *Lepidoptera* and *Diptera*. The order *Neuroptera* appeared better represented than any other, and comprised many gigantic species, most of which were referred by Hagen to extinct genera, though some of them were allied to existing American and Australian species.

From the Lias of Shambelen in the Swiss Alps about 2000 specimens had been obtained by Professor Heer, which comprised 143 species, 116 of which he had referred to *Coleoptera*, 7 to *Orthoptera*, 7 to *Neuroptera*, 12 to *Hemiptera*, and 1 to *Hymenoptera*. The majority of the insects from the Swiss Lias were small like those from British strata of the same period.

Only five insects appeared to have been found in European Triassic rocks, viz. two species from the Keuper of Vadutz and three species from the Bunter Sandstein[1] of Trebitz and Salzmunde. In conclusion, allusion was made to certain traces of insects in the Trias of the Connecticut Valley (North America) which had been referred to by Mr. S. H. Scudder.

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Geological Society of London.—I.—January 9, 1878.—Prof. P. Martin Duncan, M.B., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Great Flat Lode south of Redruth and Camborne." By Dr. C. Le Neve Foster, B.A., F.G.S.

The author described the mode of occurrence of the stanniferous deposit known as the Great Flat Lode, the mines worked in which extend for a distance of $3\frac{1}{2}$ miles, and furnish about one-eighth of all the tin raised in Cornwall. The mines in question are Wheal Uny, South Carn Brea, West Wheal Basset, South and West Wheal Frances, South Condurrow, and Wheal Grenville; and in all the lode dips at a much less angle than the average of Cornish veins, the dip at Wheal Uny being only about 46° S. Throughout the lode contains a small leader, usually only a few inches wide, occupying the space due to the shifting of the two sides of a fissure, and filled partly mechanically, partly chemically. Above or below, or on both sides of this, there is a mass of stanniferous schorl

[1] Vierteljahrsschrift der Naturforschenden Gesellschaft in Zurich, Viertes Heft, p. 297, and Heer's Urwelt der Schweiz.

rock from 4 to 15 feet wide; this contains from 1 to 3 per cent. of cassiterite, in little grains, or in strings or veins. Schorl rock, very poor in tin (locally called *capel* or *greyback*), separates the lode from the surrounding granite or killas, but passes on one side into the lode, and on the other into the granite or killas, so that no *wall* is recognizable. From these characters the author inferred that the lode and the capel are merely altered rocks, the fissure now occupied by the leader having served to bring up vapours or solutions which have entirely changed the rocks on both sides of it. In support of his opinion, the author adduced other instances of the change of both granite and killas into schorl rock; and further stated that, both at South Condurrow and Wheal Grenville, he has found in the schorl rock cavities as large as a pea, agreeing in form with crystals of orthoclase felspar.

2. "On some Tin-mines in the Parish of Wendron, Cornwall." By Dr. C. Le Neve Foster, B.A., F.G.S.

The mines described in this paper are called Balmynheer, the Lovell, and South Wendron. In the former the stanniferous deposit consists of a large irregular mass of rock 30–50 feet thick; its dip is N., at an angle of about 30°, and its strike E. 32° N., along which it has been traced for 36 fathoms. The tinny rock is separated from the granite above by a slide or vein of white clay, with a little quartz and mica, about 6 inches thick, but passes insensibly into the granite below. At the Lovell Mine there are two lodes, north and south, the former striking from 37° to 45° N. of E. and dipping N.W. at an angle of about 70°, the latter running E. 48° N. and dipping N.N.W. about 60°, so that the two lodes unite in going eastward and in depth. The lode is separated on one or both sides from the adjoining granite by a rock locally known as "cab," 6–12 inches thick, composed of quartz, mica, gilbertite, chlorite, iron pyrites, copper pyrites, and a little schorl. The lode itself shows joints which are mere planes of division in the rock, and usually have the same strike and dip; divergent joints also occur, and where these traverse the granite, they carry with them a little tin-stuff for some distance. The South Wendron Mine is worked in an irregularly cylindroid pipe of tinny rock, merging gradually on all sides into the granite; the shorter axis of its oval section is about 10 feet, while the longer axis varies from 20 to 60 feet. It dips at an angle of 49° in a direction N. 25° W. The stanniferous rock in these mines is essentially a mixture of quartz, chlorite, gilbertite, iron pyrites, and tin-ore, with zinc-blende in some cases, and usually some mica; fine needles of tourmaline occur in the cavities which it incloses. In the South Wendron Mine the southern part of the pipe is sometimes very granite-like in appearance, consisting of pink orthoclase crystals imbedded in a mass of quartz, chlorite, mica, and iron pyrites, with a little copper pyrites, fluor, and tin-ore. One specimen is a true stanniferous granite. These characters lead the author to the same conclusion he has arrived at in the case of the Great Flat Lode, namely, that these tin deposits consist entirely of altered granite, and are not ordinary mineral veins; they have no walls, but the stanniferous rock passes gradually into granite; and they show no signs of banded structure due to the successive deposition of minerals. The highly granitic character of part of the South Wendron tin deposit is strongly confirmatory of this view, which is further supported by the occurrence, in the dark mass of the so-called lode at the Lovell, of pseudomorphs of quartz after orthoclase containing a little cassiterite.

3. "On some of the Stockworks of Cornwall." By Dr. C. Le Neve Foster, B.A., F.G.S.

The author commenced by explaining that the term "Stockwork" had been derived from the German *Stockwerck*, meaning "Storey-work," in allusion to the method of working in steps or storeys in open workings originally adopted for such deposits. Their being worked in open quarries affords a good opportunity of studying the mode of occurrence of tin; and many of them are interesting on account of the small percentage of tin which will cover all expenses. Thus, in the Wheal Prosper Mine, the average amount of oxide of tin obtained per ton of stuff is not more than 3 lbs., worth, at the present price of "black tin," $4\frac{1}{2}d.$ per lb., so that the ground as it stands is only worth $13\frac{1}{2}d.$ per ton. The mine can be worked without loss on account of the softness of the rock and the large size of the grains of tin-ore, the comparative lightness of the substances associated with it, and the command of water-power.

The deposits worked as Stockworks occur in Cornwall in killas, granite, and elvans. The tin-ore, associated with quartz and with small quantities of other minerals, is found in more or less parallel thin veins and strings, dipping at a high angle, and occasionally giving off branches or uniting with one another both in dip and strike. In the killas the rock close to the veins is occasionally altered into tourmaline schist; in the granite the walls of the veins, and sometimes the whole mass of granite, are altered into greisen and schorl rock. At Carclaze the orthoclase of the intervening bands of granite has been converted into china clay, which is now the main object of the working. At Carrigan the leader sometimes adheres to the inclosing rock by one side only, the other being bounded by a clay vein which contains broken crystals of cassiterite, indicating, in the author's opinion, that a movement of the walls has taken place since the deposition of the tin-ore. Of the Stockworks in elvans the author gave a list, and remarked that the elvan of the Terras Mine is particularly interesting, as it presents a series of cavities left by the removal of orthoclase, and now being filled up with schorl and a little oxide of tin.

4. "The Precarboniferous Rocks of Charnwood Forest." Part II. By the Rev. E. Hill, F.G.S., Fellow and Tutor, and the Rev. Prof. T. G. Bonney, F.G.S., Fellow and late Tutor of St. John's College, Cambridge.

The authors described the result of the microscopic examination of a considerable series of the clastic rocks of Charnwood. Many of these, even among the finer beds, prove to be of pyroclastic origin. The coarser are generally composed of a ground mass of pulverized felspar, with viridite and some iron peroxide, full of larger fragments of felspar crystals (generally both of orthoclase and plagioclase) and lapilli. The structure of these is often distinct, some are certainly andesites, others some kind of trachyte; slaty fragments are also present, and occasional grains of quartz. The authors express their opinion that all the larger felspar crystals, and most, if not all, the quartz grains, are of clastic origin, even in the more highly altered varieties. Some of the larger fragments in the breccias were examined, and referred in part to devitrified trachytes not very rich in silica. The igneous rocks were then described. The syenites of the southern and northern districts were shown probably to belong to one system of intrusion. The hornblendic granite of the Quornden district was also described, and the microscopic structure of the different varieties of it and the above investigated. A number of igneous rocks generally forming dykes in these was described; some appear to be altered basalts, others andesites, one is a felsite, another a diorite. A group of outlying igneous rocks in the vicinity of Narborough was described. Of these, one is a quartz felsite with some hornblende; another varies between this and a quartziferous syenite; the rest are syenites, and one contains so much plagioclase as to be almost a diorite. One of the above, near Enderby, is seen to be distinctly intrusive in an altered slaty rock, which the authors have no doubt belongs to the Forest series. This discovery proves the igneous character of these rocks also, and extends the area of the slaty series five miles further south than was previously known. A section was devoted to the faults of the Forest region. Here the principal fault runs along the anticlinal axis, with a downthrow on its eastern side which diminishes from 2500 feet at the north end to 500 feet at the south end. East of this the beds seem undisturbed, but on the west they are shattered by many faults, whose course cannot be traced. These are most numerous near Whitwick. The anticlinal fault is Precarboniferous.

In conclusion, the age of the clastic and of the igneous rocks was discussed. The authors inclined to the opinion that the former are of the same age as the Borrowdale series of the Lake-district (Lower Silurian), but admitted that the recent discovery of agglomerates in the Precambriam rocks of Wales, and in the probably Precambrian ridges of the Wrekin district, weakens the arguments for this correlation. They do not think that there is any reason for supposing them Cambrian. If the Charnwood series is Lower Silurian, they think it most probable that the syenites and the Quornden granite were intruded in some part of the Old Red Sandstone period, and that the later dykes were very probably Postcarboniferous but Pretriassic.

II.—January 23, 1878.—Prof. P. Martin Duncan, M.B., F.R.S., President, in the Chair.—The following communication was read:—

"On the Secondary Rocks of Scotland. Part III. The Strata of the Western Coast and Islands." By John W. Judd, Esq., F.R.S., F.G.S., Professor of Geology in the Royal School of Mines.

The existence of scattered patches of fossiliferous strata, lying between the old gneissic rocks and the masses of Tertiary lava in the Hebrides has been known to geologists for more than a century. By Dr. Macculloch, who did so much for the elucidation of the interesting district in which they occur, these strata were referred to the Lias; but Sir Roderick Murchison showed that several members of the Oolitic series were also represented among them. Later researches have added much to our knowledge of the more accessible of these isolated patches of Jurassic rocks in the Western Highlands.

During the seven years in which he has been engaged in the study of these interesting deposits, the author of the present memoir has been able to prove that not only is the Jurassic system very completely represented in the Western Highlands, but that associated with it are other deposits representing the Carboniferous, Poikilitic (Permian and Trias) and Cretaceous deposits, the existence of which in this area had not hitherto been suspected; and by piecing together all the fragments of evidence, he is enabled to show that they belong to a great series of formations, of which the total maximum thickness could have been little, if anything, short of a mile.

The relations of the scattered patches of Mesozoic strata to the older and newer formations respectively are of the most interesting and often startling character. Sometimes the Secondary rocks are found to have been let down by faults, which have placed them thousands of feet below their original situations in the midst of more ancient masses of much harder character. More usually they are found to be buried under many hundreds, or even thousands of feet of Tertiary lavas, or are seen to have been caught up and inclosed between great intrusive rock-masses belonging to the same period as the superincumbent volcanic rocks. Occasionally the only evidence which can be obtained concerning them is derived from fragments originally torn from the sides of Tertiary volcanic vents, and now found buried in the ruined cinder-cones which mark the sites of those vents. In some cases the mineral characters of the strata have been greatly altered, while their fossils have been occasionally wholly obliterated by the action of these same igneous forces during Tertiary times.

In every case the survival to the present day of the patches of Secondary rocks can be shown to be due to a combination of most remarkable accidents: and a study of the distribution of the fragments shows that the formations to which they belong originally covered an area having a length of 120 miles from N. to S., and a breadth of 50 miles from E. to W. But it is impossible to doubt the former continuity of these Secondary deposits of the Hebrides with those of Sutherland to the north-east, with those of Antrim to the south, and with those of England to the south-east. From the present positions of the isolated fragments of the Mesozoic rocks, and after a careful study of the causes to which they have owed their escape from total removal by denudation, the author concludes that the greater portion of the British Islands must have once been covered with thousands of feet of Secondary deposits. Hence it appears that an enormous amount of denudation has gone on in the Highlands during Tertiary times, and that the present features of the area must have been, speaking geologically, of comparatively recent production—most of them, indeed, appearing to be referable to the Pliocene epoch.

The alternation of estuarine with marine conditions, which had, on a former occasion, been proved to constitute so marked a feature in the Jurassic deposits of the Eastern Highlands, is now shown to be almost equally striking in the Western area; and it is moreover pointed out that the same evidence of the proximity of an old shore-line is exhibited by the series of Cretaceous strata in the West.

The succession and relations to one another of the series of deposits, now described as occurring in the Western Highlands, is given in the following Table:—

*Miocene Volcanic and Intervolcanic Rocks.*

| | | Maximum thicknesses. feet. |
|---|---|---|
| | UNCONFORMITY. | |
| Cretaceous. | 1. Estuarine clays and sands with coal | 20+ |
| | 2. White Chalk with flints (Zone of *Belemnitella mucronata*) | 10+ |
| | 3. Estuarine Sandstones with coal | 100 |
| | 4. Upper Greensand beds | 60 |
| | UNCONFORMITY. | |
| Jurassic. | 5. Oxford clay | ? |
| | 6. Great Estuarine Series | 1000 |
| | 7. Lower Oolite | 400 |
| | 8. Upper Lias | 100 |
| | 9. Middle Lias | 500 |
| | 10. Lower Lias | 400 |
| | 11. Infralias | 200 |
| | 12. Poikilitic | 1000+ |
| | UNCONFORMITY ? | |
| | Carboniferous strata (Coal-measures). | |
| | UNCONFORMITY. | |
| | *Old Gneiss Series and Torridon Sandstones.* | |

Although no traces of the Upper Oolite or the Neocomian formations have as yet been detected in the Western Highlands, yet it is argued that when we consider how enormous has been the amount of denudation, and how singular the accidents to which all the existing relics of the Secondary period have owed their escape from total destruction, we cannot but regard it as a most rash and unwarrantable inference to conclude that no deposits belonging to those periods were ever accumulated within the district under consideration.

The Carboniferous strata of the Western Highlands have been detected at but a single locality; and even there, being exposed in a series of shore reefs that are only occasionally well displayed, can only be studied under favourable conditions of tide and wind.

They consist of sandstones and shales with thin coaly seams, and their age is placed beyond question by the discovery in them of many well-known plants of the Coal-measures, including species of *Lepidodendron, Calamites, Sigillaria,* and *Stigmaria.*

The Poikilitic strata consist of conglomerates and breccias at the base, graduating upwards into red marls and variegated sandstone, which contain concretionary limestones and occasional bands of gypsum. These strata have not as yet, like their equivalents in the Eastern Highlands (the Reptiliferous Sandstone of Elgin and the Stotfield rock), yielded any vertebrate remains. They were evidently deposited under similar conditions with the beds of the same age in England, and are not improbably of lacustrine origin.

The Jurassic series presents many features of very great interest. The Infralias is better developed than is perhaps the case in any part of the British Islands; and in the district of Applecross a series of estuarine beds, containing thin coal-seams, is found to be intercalated with the marine strata.

The Lower Lias, in its southern exposures, presents the most striking agreement with the equivalent strata in England, but when traced northwards exhibits evidence of having been deposited under more littoral conditions; the lower division (Lias $a$, Quenstedt) is represented by a great thickness of strata; while the upper (Lias $\beta$) is absent or rudimentary. The Middle Lias is grandly developed, and consists of a lower argillaceous member and an upper arenaceous one, the united thickness of which is not less than 500 feet. The Upper Lias singularly resembles in the succession of its beds, and its palæontological characters, the same formation in England. The Inferior Oolite is formed by series of strata varying greatly in character within short distances, and betraying sufficient signs of having been accumulated under shallow-water conditions. Above the Inferior Oolite we find a grand series of estuarine strata, partly arenaceous and partly calcareo-argillaceous; and this is in turn covered conformably by an unknown thickness of blue clays with marine fossils of Middle Oxfordian age. At the very lowest estimate, the Jurassic series of the Western Highlands could not have had a thickness of less than 3000 feet!

The Cretaceous strata of the Western Highlands, though of no great thickness, are of surpassing interest. They consist of two marine series alternating with two others of estuarine origin. At the base we find marine deposits of Upper Greensand age, strikingly similar to those of Antrim, but in places passing into conglomerates along old shore-lines. Above the Upper Greensand beds occur unfossiliferous sandstones, in which thin coal-seams have been detected, and these are in turn covered by strata of chalk, converted into a siliceous rock, but still retaining in its casts of fossils (*Belemnitella, Inoceramus, Spondylus,* etc.), and in its beautifully preserved microscopic organisms (*Foraminifera, Xanthidia,* etc.), unmistakable proofs of its age, and the conditions of its deposition. Above this representative of the highest member of the English Chalk there occur argillaceous strata with coal-seams and plant-remains which are perhaps the equivalent of younger members of the Cretaceous series, not elsewhere found in our islands, or, it may be, they must be regarded as belonging to periods intermediate between the Cretaceous and Tertiary epochs. It is greatly to be regretted that these Cretaceous deposits of the Western Highlands are so unfavourably displayed for our study as to present scarcely any facilities for the collection of their fossils; for these, if found, might be expected to throw a flood of light on some of the most obscure palæontological problems of the present day.

Although the comparison and correlation of the Secondary strata of the Highlands with those of other areas, and the discussion of the questions of ancient Physical Geography thereby suggested, are reserved for the fourth and concluding part of his memoir, the author takes the opportunity of making reference, in bringing the present section of his work to a close, to several problems on which the phenomena now described appear to throw important light. In opposition to a recent speculation which would bring into actual continuity the present bed of the Atlantic and the old Chalk strata of our island, he points to the estuarine strata of the Hebrides as demonstrating the presence of land in that area during the Cretaceous epoch. He also remarks on the singular agreement of the conditions of deposition of both the Silurian and Cretaceous strata of the Scottish Highlands and those of the North American Continent. But he more especially insists on the proofs, which we now have, that the Highlands of Scotland, as well as the greater part of the remainder of the British Islands, were once covered by great deposits of Secondary strata, and that the area has been subjected to enormous and oft-repeated denudation. He dwells on the evidence of the vast quantities of material which have been removed subsequently to the Mesozoic and even to the Miocene period, and he maintains the conclusion that many, if not all, of the great surface-features of the Highlands must have been produced during the very latest division of the Tertiary epoch, namely the Pliocene.

## CORRESPONDENCE.

### INDUCED STRUCTURE IN STONE.

Sir,—A very remarkable exfoliated piece of sandstone from an urn forming part of a tombstone was brought me by a mason a short time ago. It is from the base or pillar of the urn itself, and measures 9 in. by 5 in., varying in thickness from $\frac{1}{16}$ to $\frac{1}{10}$ of an inch. The outside surface had been worked and rubbed in forming the urn, and one side of the exfoliated piece consists of this worked surface perfectly preserved. The pedestal has a horizontal and vertical curvature, and when laid on the table the exfoliated piece rises fully two inches in the quickest part of the curve. I exhibited this specimen at the last meeting of the Liverpool Geological Society, when some scepticism was evinced as to its being genuine sandstone. I have since examined the tombstone, which is in St. James's Cemetery, and find that it is genuine stratified sandstone, which the microscope had before proved. It is of extremely fine grain, and I can detect nothing but minute grains of silex in its composition. Hydrochloric acid does not affect it. The stone, I am told, comes from somewhere near Burnley, and it evidently belongs to the Carboniferous group. The bedding of the stone in the base of the tomb shows in rusty iron streaks, and exposure discolours it in places. I have since receiving the specimen, on visiting Canterbury Cathedral, noticed that the surface of the Purbeck marble shafts inside the choir exfoliate, following the worked surface, but not nearly in so regular a manner as indeed we would anticipate from its fossil structure.

It appeared to me very remarkable that the exfoliation should follow so truly the worked surface of the stone, only varying the $\frac{1}{32}$ of an inch, especially in the case of a bedded sedimentary rock, instead of following the planes of bedding as is usually the case. I am informed it was customary to oil the stones in this Cemetery with a view to their preservation. Can this have effected it? I can find no trace of oil in it now.

T. Mellard Reade.

Park Corner, Blundellsands.

Note.—As bearing upon the above letter, we may state that Prof. Morris has for twenty years been accustomed to direct the attention of geological students to the curious molecular change produced by "dressing" stone, whether for architecture or statuary. From his careful observations it would appear that most compact stones when "dressed" seem less disposed to follow their original inclination to break up along certain planes, and exhibit a stronger tendency to exfoliate in layers parallel to the artificially-worked surface of the stone. One of his favourite illustrations was a gigantic arm of syenite or red granite, once forming part of a colossal statue of Thothmes III., discovered by Belzoni in 1818, lying in the sand in the Karnak quarter of Thebes. This arm, which now forms one of the most striking objects in the Egyptian Gallery of the British Museum, exhibits near the shoulder a tendency to exfoliate in regular concentric layers corresponding with the worked and polished surface of the limb. Mr. Mellard Reade will, we feel sure, be pleased to find that his idea of the "induced structure in stone" has the support of so distinguished an authority as that of Professor Morris.—Edit. Geol. Mag.

## MISCELLANEOUS.

Marine Fossils in the "Gannister Beds."—Mr. G. A. Lebour, writing from the College of Physical Science, Newcastle-on-Tyne, to "*Nature*," announces the discovery (on the 9th Feb.) of marine fossils in the Lower Coal-measures or "Gannister beds" of Northumberland between Stocksfield Station and Whittonstall. Hitherto no marine forms had been found in this series.

Academic Honour.—At a congregation of the Senatus Academicus of the University of St. Andrews, on Saturday, February 9th, the honorary degree of LL.D. was conferred on Henry Woodward, F.R.S., F.G.S., of the British Museum.

THE

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## ORIGINAL ARTICLES.

### I.—The Age of the World as viewed by the Geologist and the Mathematician.

By T. Mellard Reade, C.E., F.G.S.

UNTIL Geology began to take the place of a science, few, if any, troubled themselves about the age of our planet. The habit of thought, created partially by the Mosaic Cosmogony, which led us to look at all the natural features around us as if but just freshly formed by the hands of the Creator was not favourable to any such inquiry.

To think that everything, as we see it now, is as it always was, is easy and natural, saves trouble, and is a habit of mind deeply engrained in human nature. It is only within the last few years that we have been able to dispossess ourselves of this notion with regard to animated nature. Special creation of everything as we see it answers best to our anthropomorphic ideas, derived from a contemplation of man's creative efforts. The conception of innate energy, continuity, and evolution, is a higher stage of thought, only arrived at by close observation of, and reasoning on, the relations of natural phenomena.

So far as my knowledge of history extends, the geologist was the first to raise the question of the Earth's age. Astronomy did not lead to its contemplation. No one that I am aware of, before geological inquiry, said the Earth must be so many millions of years old, because the rate at which the temperature increases downwards shows that it must at least have taken so long to cool from the time when it was an incandescent globe. Yet it is the astronomer who inferred long since that this Earth of ours, from its spheroidal form, must originally have been in a molten state, and the same elements existed at the time for the calculation of its age from a physical basis that do now. Why then was it not done? Simply because it did not strike any one that it must be extremely ancient, as the evidences of age did not come prominently forward.

When, however, the curiosity of the geologist, delving into the Earth's crust brought to light the fact that under thousands of feet of rock lay the evidences of the existence, at an earlier period, of a fauna and flora differing from those of the present day,—of rivers, seas and continents now buried below deposits to which those obscuring the remains of ancient Troy are as a film of dust,—it was impossible any longer to resist the conviction that the age of the world was enormously greater than any one had before contemplated.

So averse, however, is the human mind to receive new impressions, that the first geologists had to shorten the life of the world by periodical convulsions and the assumption of more potent natural causes in the earlier periods of the Earth's history.

In this again they were assisted by another vice of the mind—that of generalizing from small data. Faults, foldings of the strata, and other evidences of former volcanic activity, that have been since proved to be only local phenomena, were assumed to have extended all over the Earth at the same time, and to have separated its history into "periods." This I call constructive geology, due to an unscientific use of the imagination. Yet those crude and hasty generalizations were not to be wondered at; for the peculiar scientific habit of thought engendered by sound geological reasoning had not then been acquired.

To Hutton is due the merit of placing geological investigation on a sound basis, and to Lyell philosophical geology almost owes its existence.

The conception of the possibility of explaining all the phenomena of the Earth's crust by agencies at present at work, lies at the foundation of all geological reasoning. It is one, however, that does not necessarily commend itself to the judgment at first sight, because there are no *a-priori* improbabilities in conceiving that agencies may have been at work at former periods of which we now know nothing. If, however, we attentively study the Earth's crust, we become gradually convinced that the agencies we are acquainted with are competent to explain all the complicated phenomena with which it abounds, and not only so, but that no other agencies can satisfactorily explain them.

Therefore, instead of a playful exercise of fancy, we begin our investigations on a sure foundation—so sure indeed that no geologist, so far as I am aware, has been compelled to adopt any other hypothesis, though of course different opinions are held with regard to the relative activity of these forces at various stages of the history of the Earth.

Geology, then, is a pre-eminently practical common-sense science, because it is always testing its conclusions by reference to the Earth itself. The reasoning is essentially of an inductive cast. It is necessarily a safe science, for it cannot get far on the wrong road without being set right. Astronomy is a more exact science; the relations it sets itself to investigate are simple ones—mechanical conceptions capable of mathematical demonstration and verification by exact measurement. When I say the relations it investigates are simple, I say it with the profoundest respect; for the solutions of some of these problems are among the greatest triumphs of the human mind. The method of procedure is, however, essentially different, and the attempt to displace the geological by the mechanical method in developing the geological history of the Earth is, I trust to be able to show, one not likely to succeed.

To Sir Wm. Thomson is due the merit of first attempting to apply the physical, or what I prefer to call the mechanical method, to the determination of the age of the Earth. Three ways have been suggested by him for doing this; but it is only to the one on which he most relies—founded on the increase of temperature proved by experiment to take place from the surface downwards—that I propose to refer. The calculation is based upon the assumption that the whole mass of the Earth was at one moment at an incandescent heat estimated at 7000° Fahr. warmer than our present surface temperature; that it was at an initial moment at this uniform temperature throughout, from which time it has since been uniformly cooling through being exposed to the present surface temperature. By a mathematical process, the experimental elements of which depend upon the average thermal conductivity of the materials of the Earth, and the average augmentation of heat downwards, he arrives at the conclusion that it is improbable more than 100 millions of years have elapsed since the surface of our globe became habitable.

Now the geologist neither denies nor affirms that the Earth was once an incandescent mass. By analogy it is probable at the present time the heat goes on increasing downwards until incandescent matter is reached: but it cannot be experimentally proved; though volcanic action now existing in various parts of its surface points to the same conclusion. It is also not an improbable further deduction that at one time the globe was incandescent from the centre to the surface. Arguing from an hypothesis of this nature, and reconstructing the globe upon it, is what the cosmogonists used to do; but it is a method alien to geology, which aims at interpreting the history of the Earth by an examination of its rocks.

Now, for a calculation such as this one suggested by Sir Wm. Thomson to command assent, it must be based upon very accurate experiment and observation, that the material points on which it hinges may be first proved beyond doubt. He says,[1] "Whatever the amount of such effects is at any one time, it would go on diminishing according to the inverse proportion of the square roots of the times from the initial epoch. Thus, if at 10,000 years we have 2° per foot of increment below ground,

| | | | | | |
|---|---|---|---|---|---|
| at | 40,000 | years we should have | 1° | per foot | |
| | 160,000 | ,, | ,, | $\frac{1}{2}°$ | ,, |
| | 4,000,000 | ,, | ,, | $\frac{1}{10}°$ | ,, |
| | 100,000,000 | ,, | ,, | $\frac{1}{50}°$ | ,, ." |

If, therefore, through any error in the calculation, arising from incorrect inference from experiment, the increment of temperature should be not 2° but 4° per foot at the end of the first 10,000 years,[2] the times would be multiplied fourfold, and would stand thus:

[1] Treatise on Natural Philosophy, Thomson and Tait, p. 721.

[2] Prof. Helmholtz has calculated, from the rate of cooling of lavas, that the earth in passing from 2000° to 200° C. must have taken *three hundred and fifty millions of years!* Dana, commenting upon this, says: "But the temperature when the Archæan Time (Laurentian and Huronian periods) ended was probably not over 38° C. (100° Fahr.)." Dana's Manual of Geology, second edition, p. 147.

| | | | | |
|---|---|---|---|---|
| At | 40,000 | years | 2° | per foot |
| | 160,000 | „ | 1° | „ |
| | 4,000,000 | „ | $\frac{1}{5}$° | „ |
| | 100,000,000 | „ | $\frac{1}{25}$° | „ |
| | 400,000,000 | „ | $\frac{1}{50}$° | „ |
| | 1,600,000,000 | „ | $\frac{1}{100}$° | „ |

So, if we assume the increment at 1° in 100 feet, and there are to my mind as good reasons to do so as to assume 1° in 50 feet, the observations being, as I shall show, so contradictory and inconclusive, it would in this case bring up the age of the world to 1600 millions of years. These values may hold good with regard to a homogeneous mass of uniform conductivity, but not in the case of a globe built up of strata of varying conductivities. Let us, for example, consider how the effect would be varied in a very simple case.

First, we may assume a globe, the mass of which below a certain depth is of unknown materials and unknown conductivity,—as is really the case with the Earth, but that it is a reservoir of heat which it transmits to a surface layer of rock 3500 feet deep,—having a conductivity of ·006,[1] and that in 100 million years it has cooled down so that this surface stratum possesses an increment of $\frac{1}{50}$ of a degree of heat per foot.

Secondly, let us assume a similarly unknown globe having a surface layer of rocks also 3500 feet deep, but composed of two equal layers, the external one having a conductivity of ·003, and the inner layer ·009, the average conductivity of the two strata would be ·006, the same as before; but as the increment of heat varies inversely as the conductivity, with the same flow of heat, the outer layer would increase in temperature at the rate of $\frac{1}{25}$ of a degree per foot, and the inner one $\frac{1}{75}$ of a degree per foot. Thus the average rate of increase of temperature with the same loss of heat taking place would be $\frac{1}{38}$ of a degree per foot.[2] The conductivity averaging the same as in the first example, and the increment of heat being greater, the inferred age of the globe would be less than 100 million years.

But, as we have already assumed, only the same loss of heat taking place, the actual age of the globe, if its constitution in other respects were the same, in both cases would appear to be more correctly estimated at the same figure. Should, however, the calculation be based upon the rate of increase of the *outer* layer and the average conductivity of the two layers, a practical error that might readily occur in estimating the increment of heat in borings, and the average conductivity of the materials of the Earth within our reach, the age of the Earth would be inferred as only 25 million years.[3] It is, however, quite evident that all these conclusions

[1] I adopt in all cases the British Association Unit of Conductivity, viz. centimetre—gramme—second.

[2] This is arrived at by calculating the total increase of heat downwards in both cases and dividing by 3500 feet the total thickness of the strata.

[3] In these illustrations, and my reasoning throughout, for the sake of simplicity I omit all consideration of specific heats, as they do not affect the line of argument adopted, except that in nature they further complicate the thermal effects.

cannot be right, and, further, that any estimate of age from the thermal condition of the crust may be further vitiated by our ignorance of the nature, constitution and materials of the globe underlying the outer strata.

These, I think, are the nature and character of the errors incidental to any calculation of the actual age of the Earth from the outer crust of sedimentary rocks. Possessing as they do varying conductivities, and being of various thicknesses, the average conductivity of the whole has not improbably been overestimated, and the average increase of heat overstated, while the combined resistance of strata of varying conductivities may be greater to the passage of heat across them than what would be inferred, even from a correct average, as was shown to be the case in my second theoretical example.

If, in addition, we assume that our crust rests upon a basement of rocks analogous to granite possessing high conductivities, it is evident the more non-conducting envelope would be retained at a high increment of temperature for a longer period than if the whole mass of the Earth underneath possessed only the same conductivity as the crust. Nor should it be lost sight of in this inquiry, that the strata we are acquainted with are not cooling down from a state of fusion, but are deposits laid down upon the surface and gradually heated from below. This, again, obscures the results, and, indeed, the question becomes so exceedingly complicated, that it is beyond my powers to unravel; but it is not inconceivable that an initial increment of temperature might be retained in this way for a lengthened period.

The cumulative results of these possible errors might then at least quadruple the maximum age of the Earth as inferred from calculation. At all events, I trust that I have shown the extremely untrustworthy character of averages in such an investigation. But these are not by any means all the arguments that can be urged against the method—the data, as ascertained by experiment, being of a complicated and contradictory character.

Before dealing with the purely geological aspect of the question, it will be well shortly to examine the nature and extent of the data forming the vital elements of the mechanical problem.

Sir W. Thomson states the variation of the increase of temperature to be from $\frac{1}{110}$ of a degree Fahr. in some localities, to as much as $\frac{1}{15}$ in another per foot of descent, but $\frac{1}{50}$ is accepted as a rough mean.

The Reports on Underground Temperature by the British Association show most remarkable differences in localities not very far apart. Thus, according to experiments made by Mr. Fairbairn at Astley Pit, Duckinfield, Cheshire, the average rate of increase was 1° every 80 feet for a depth of 685 yards; while similar experiments at Rose Bridge Colliery, Ince, near Wigan, for a depth of 815 yards, gave an average increase of 1° in every 54·3 feet.[1] Again, the rate of increase in some of the wells in Paris is 1° for every 50 to 60 feet; while the great well of La Chappelle at Paris showed, at a depth

[1] British Association Report on Underground Temperature, 1870, pp. 31–2.

of 600 mètres, an average increase of 1° in 94·3 feet.[1] In experiments made at Przibram, in Bohemia, by Herr Johann Grimm,[2] Director of the School of Mines, in a depth of 1900 feet, there was an increase of 1° in every 141 feet. The experiments at the Mont Cenis Tunnel show an increase of 1° in 93 feet, without correction for the convexity of the ground.

If, however, there exist this variation in the average increase of temperature of each total depth of rock penetrated, there is still more variation in the rate of increase in different parts of the same bore, the variation in the Bohemian mine being from 1° in 45 feet to 1° in 1400 feet.

On the other hand, if we refer to the conductivity of certain rocks, we find, according to the revised scale in the experiments made by Herschel and Lebour,[3] the thermal conductivities vary from ·00882 for opaque white quartz to ·00065 for cannel coal. I understand Sir W. Thomson's average was founded upon the conductivity of only two descriptions of rock, viz. Calton trap rock and Craigleith sandstone, estimated respectively by him, if reduced to British Association units, at ·00266 and ·00689.[4]

Without going further, I think sufficient has been said to show on what an insecure basis this tremendous superstructure of inference has been built. From experiments only made in a few places, and necessarily upon rocks, geologically speaking, subject from time to time to great fluctuations of temperature, and in mere scratches in the Earth's surface, through all manner of variations, the first average necessary to the calculation has been educed, viz. a ratio of increase of heat of 1° per 50 feet.

The average conductivity is a still greater assumption, because, in the first place, the relative amount of each class of rock composing the crust of the Earth and its conductivity should be calculated, which is not done, and would prove very difficult to even approximately estimate. Neither are laboratory experiments on conductivity conclusive, as a mass of rock through its structure may behave in a different way to a small piece, while the impossibility of testing in any way the average conductivity of the materials of the interior of the Earth, subject to such enormous pressure and heat, is apparent. It is also not at all improbable that frequent variations of strata, possessing different conductivities, may create interference in the transmission of heat; for it is proved that laminations increase the non-conducting property of rock across the planes of lamination.

If we turn from this most complex and difficult problem, to study the history of the Earth, and form our views by induction from observation, we find that from the earliest periods to the present time the known crust of the Earth has been in continual process of construction, or reconstruction, by sedimentary and volcanic deposits,

[1] *Ibid.* 1873, p. 253. [2] *Ibid.* 1875, p. 15.

[3] British Association Report on Thermal Conductivities of certain Rocks, 1875, p. 57.

[4] The estimate is really made in terms of the thermal capacity of the unit of bulk, which is averaged at 400; the unit in length being a British foot, and unit of time a year.

the result of atmospheric waste and volcanic emissions and intrusions; that this composite body, called the crust, has, from time to time, throughout all geologic ages, been not only broken up, but heated matter has been injected into it[1] or thrown over it; and that this has occurred at one time or another over the whole of the known globe.

Not only has this been the course of events, but the great mountain chains—the Andes, the Alps, the Pyrenees, and the Himalayas[2]—have been thrown up at a comparatively recent time, geologically speaking, so that the more we restrict the age of the world, the hotter should the strata be under those great continents on which these mountain chains rest.

To get out of this dilemma is impossible; for we cannot consider these volcanic outbursts as mere local effects, the volcanos at present active being in lines thousands of miles long, the effect of deep-seated forces probably connected with central heat, but, even if not, fed by lakes of molten rock sufficient to set all calculations of secular cooling at defiance.[3]

A study of existing volcanos also shows that molten rock at the surface does not act now in the way Sir W. Thomson assumes it did in his hypothetical incandescent globe. Why it should not I cannot conceive. In the volcano of Kilauea, Hawaii, in the Sandwich Islands, the molten rock boils up in the crater, while waves of red-hot matter dash against the surrounding cliffs, and break in incandescent spray.[4] If molten rock does this now, why should it in the first formation of the globe set suddenly solid from the circumference to the centre, as required by Sir W. Thomson's theory, and ever afterwards be gradually cooling as an iron shot might cool from a white heat?

[1] Prof. Judd points out, in his admirable "Contributions to the Study of Volcanos," Geol. Mag. 1876, p. 211, that in the Southern Tyrol, during the Permian period, "enormous masses of volcanic rock were erupted, leading to the formation of volcanic mountains at least 8,000 feet to 9,000 feet high." The great "Whin Sill" has also been proved by Topley and Lebour to be a vast intrusive sheet. Innumerable similar examples may be quoted; and as it is usually only by denudation we get a glimpse of those volcanic rocks occupying the interior of the crust, we may be sure there are many others unknown because undisclosed.

[2] Ramsay, Geological History of some of the Mountain Chains and Groups of of Europe, Mining Journal, 1875. Judd, Contributions to the Study of Volcanos, pp. 133-41.

[3] As a proof of the failure at present to establish any law of increase of temperature, the remarkable temperature results in the boring at Sperenberg, near Berlin, 4172 feet deep, may be quoted. In this case the first 283 feet were in gypsum, with some anhydrate, and the remainder entirely in rock-salt. Although rock-salt possesses a considerably higher conducting power than even quartz, being ·01154, and more than twice that of Aberdeen granite, the rate of increase of temperature averaged 1° per 51·5 feet. (British Association Report on Underground Temperature, 1876, p. 206.) If the rates of increase should be inversely as their conductivity, on the supposition of an uniformly cooling globe, the increase of temperature should, compared with Mont Cenis, not be more than 1° per 200 feet. Does it not suggest that the source of the heat must be nearer the surface, or that there exists beneath, some mass of rock abnormally heated?—a supposition consistent with the geological fact already stated of the intrusion of heated matter into the crust of the globe and at various epochs of its history.

[4] Log Letters of the *Challenger*.

Reasoning from observation, as a geologist is bound to do, the greater probability is that the surface would become crusted over in a way that the lava in a volcano becomes crusted over, and that the surface rock would be of a vesicular character of less specific gravity than the molten matter. Nasmyth's theory of the volcanos of the Moon[1] is founded on the supposition that the molten matter expands in cooling, giving examples in support of his idea, such as the fact that a lump of cold cast-iron will float in molten iron. Sir W. Thomson assumes the rock will cool, contract and sink in the molten mass. Which is right? Nasmyth certainly has had the most practical experience of molten metals! That a cooling globe solidifies from the surface, I think the Moon is a striking proof.[2]

The crust would most probably solidify and break up again and again, and hot materials be injected into, through, and on to the surface.

A glance at a map of the volcanos of the Moon should satisfy any one on this point, for there are the evidences of almost countless myriads of volcanic rings or craters, covering the whole surface and superimposed or breaking through one another in a most remarkable way. Observation, then, tells us that a crust will most likely form on a globe of molten rock. Now, in the case of the Earth, comes in the question of denudation; for no sooner is a sufficient crust formed than the aqueous vapours and atmospheric agencies begin to eat it down, and thus we have a composite crust of sedimentary and volcanic materials, such as the geologist is acquainted with as existing in Nature. There is also this fact in favour of a retention of heat by the globe, that pumice rock, and any rock of a loose or vesicular nature, possesses small conducting power,—the proportion of absolute resistance to the passage of heat being as 1818 in dry pumice to 87 in rock-salt.

The laminations and alternations of beds is also, I strongly believe, favourable to the retention of heat,[3] so that we see a coating must be gradually formed round our incandescent globe like the felt round a steam boiler.

This speculation, though interesting, is rather outside of true geological inquiry; it is beginning at the wrong end. No one yet has ever had a glimpse of this primitive globe; for though we have a knowledge of a thickness of rock estimated at from 14 to 17 miles, the base is practically the same as the topmost story of the superstructure. These original crusts have most likely been broken up, melted and destroyed long since, as sediments have been also melted and destroyed.

Much more may be said on the subject, but I trust enough has been shown to prove that the hypothetical way of treating such

[1] The Moon as a Planet, as a World, and a Satellite, Nasmyth and Carpenter.

[2] Mr. Mallet has controverted Nasmyth's conclusions, Proc. Roy. Soc. 1874, p. 366. Nevertheless, he admits the fact of certain pieces of cold cast-iron floating upon molten iron.

[3] In my Presidential Address to the Liverpool Geol. Soc. Session 1875–6, "On the Moon and the Earth," it is suggested, p. 89, that "the sediments accumulating on the Earth from age to age must act as a non-conducting envelope."

problems, however clever, ingenious and interesting, is unreliable. Geology demands that a thing should be tested as you go along; for so little is really known of the physics of the Earth that we continually find facts in discordance with preconceived notions, though, when once known, it is easy to see that such and such a thing *might* have been predicted by theory.

It is proverbially easy to prophesy after a thing has happened, and it is just as easy to see that any proved fact is in accordance with the laws of physics. Nevertheless, the observer is continually discovering new things that no one predicts. If there is any one thing that physicists ought to have predicted, it is that the bottom of the ocean is uniformly occupied by water of a very low temperature. Now I think there are few physicists who would not have supposed that the secular cooling of the Earth would, to some degree, have influenced the bottom water of the ocean that must have travelled thousands of miles in contact with it, yet the *Challenger* temperature soundings prove that it has no appreciable effect.[1]

It is impossible in this space to explain the way the geologist approximates to the immense age of the Earth, and as I have already elsewhere[2] attempted the calculation on a geological basis, it is thus less necessary for me to do so now. A calm investigation of all the multitudinous facts which necessarily enter into the problem satisfies me, at all events, that no case has been made out for restricting the age of the Earth below that demanded by Geology, even on the assumption of a globe of molten materials to commence with. According to Sir W. Thomson's expressed opinion, "The general climate cannot be sensibly affected by conducted heat at any time more than 10,000 years after the commencement of superficial solidification." So that as the rate of deposition of sedimentary rocks cannot by this hypothesis have been affected by the interior heat of the Earth, it tends to show it is a reasonable assumption on the part of the geologist that the rate of formation of these rocks, dependent on atmospheric degradation, was in former ages very much what it is at present.[3]

I am also of opinion that the rate of increase of underground temperature has, probably, been for long ages past very much what it is now; for if I have shown that the interior heat of the Earth is introduced into the crust by intrusion, as well as by conduction, there is even now, according to Sir W. Thomson's showing, a vast reservoir of unexhausted heat; nor must we forget that the present crust of the Earth is not an originally formed product, but one built upon

[1] Mr. Croll (Climate and Time) attempts to explain why the secular cooling of the Earth does not affect the bottom water of the Ocean, but the explanation comes after the knowledge of the fact.

[2] "On Geological Time," Presidential Address, Liverpool Geol. Soc. Session 1876-7.

[3] Sir W. Thomson, however, infers, that as the Sun must have been hotter in former ages, the atmospheric agencies were then more potent; but this is all pure hypothesis, no proofs that they were being adduced. Mr. Croll again has his own hypothesis on the subject, but the fact is we know absolutely nothing of the Sun's heat, and cannot safely reason on conjectures.

the pre-existing materials: so that if we assume a freer circulation of underground heat below this crust than through it, as I think volcanic action indicates, and a successive building up of crust upon crust as it is destroyed from below, together with an intrusion of melted materials which from time to time, as we know, has taken, and is taking place, the conditions of varying increments of heat actually met with in equal spaces downwards will be pretty well fulfilled. That this circulation of heat takes place at great depths is rendered probable by the alteration of the positions of volcanos from time to time in the Earth's history, by the tremendous evidences of volcanic effects in Tertiary times, and by existing volcanos.[1]

Facts are safer than theories, and as at 100 miles deep, even according to Sir W. Thomson's theory, the rocks now must be at 7000° Fahr., if this circulation of internal heat takes place as I suggest, there is sufficient store of heat in the Earth now to carry us on comfortably for another 1000 million of years, without those reconstructive agencies on which our existence depends becoming impotent.

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## II.—Geological Time.

By C. Lloyd Morgan, F.G.S., A.R.S.M.

(Part I.)

One of the most important questions which modern geologists have to answer is that which refers to the duration of Geological time. How long is it since the Glacial epoch? What was the date of man's appearance on the earth? How many ages have rolled by since the earth first became the habitation of organized beings? Such are the questions, daily repeated, to which we must make some answer, or, if need be, honestly confess our ignorance.

It is interesting to notice the change which has taken place, within the last century or so, in the opinions of educated men on these fundamental questions. At the beginning of the present century it was the almost universal belief, that the earth had been in existence some 5800 years, and the human race some six days less. *Now* there are few men of ordinary education who do not admit the great antiquity of man, and the vast age of the globe which he inhabits; while theologians vainly endeavour to persuade us that the Mosaic six days meant six long geological periods, forgetful that Moses (if indeed he was the author of Genesis) was writing a history of the Jewish race and their beliefs, so far as he could gather it from tradition, not a treatise on Geological Cosmogony.

But just as a young man who has been subject to too great and unwise restraint, when he has once broken the fetters, rushes into

[1] A study of Mr. Darwin's "Geological Observations," published first as early as 1844, will, I think, convince the most sceptical of the continued activity of the volcanic forces in South America on a tremendous scale, which must leave some impression on underground temperature there in future ages, though I agree with Prof. Judd that there has not necessarily been the same actual display of energy at every period of the Earth's history. This is dependent on many causes, which I hope to be able to further explain at a future time.

too great and equally unwise excess, before he settles down into the steady earnestness of sober manhood, so did geologists, when they had freed themselves from the restraint imposed upon them by a belief in the truth of the Mosaic account of Creation, make too great drafts on the bank of Geological Time. "In the economy of the world," said Hutton, "I can find no traces of a beginning, no prospect of an end." Geological Time was considered illimitable, and a false analogy was set up between the boundless infinity of space and the vast immensity of past time. Geologists began to speak of millions of years as mere moments in the antiquity of the earth's history. Thousands of millions, billions, and "vast œons" of past time were spoken of with impunity. This error, for we shall shortly see that it was an error, arose partly no doubt from our utter inability to conceive periods of time which greatly exceed in length the three or four thousand years with which the history of nations has to deal. Directly we cease to have a clear mental image of the length of time spoken of, and can no longer refer it to any standard, we get into the region of mere empty words which mean nothing. "A million of years"—it is easily said, but really conveys very little to the mind. Mr. Croll, feeling the truth of this, helps us to conceive this immense period of time. "There is one way," he says, "of conveying to the mind some idea of what a million of years really is. Take a narrow strip of paper, an inch broad, or more, and eighty-three feet four inches in length, and stretch it along the wall of a large hall, or round the walls of an apartment somewhat over twenty feet square. Recall to memory the days of your boyhood, so as to get an adequate conception of what a period of a hundred years is. Then mark off from one of the ends of the strip one-tenth of an inch. The one-tenth of a inch will then represent one hundred years, and the entire length of the strip a million of years. It is well worth making the experiment," Mr. Croll adds, "just in order to feel the striking impression that it produces on the mind."

Having grasped in some degree the vast period of time conveyed by that little phrase "a million of years," the geologist is in a better position to hear patiently the arguments brought forward by physicists for the definite limitation of that time, which the School of Uniformity had taught him to consider as indefinite in length. Of those who have made this subject their special study, Sir William Thomson takes the lead, and he has considered the matter from more than one point of view.

I will here extract a short description of his results from Professor P. Guthrie Tait's "Recent Advances in Physical Science," in which there is a brief *résumé* which "contains nearly all that is accurately and definitely acquired to science upon the subject." In the first place, then, Sir William Thomson takes into careful consideration the facts connected with the internal temperature of the earth. It is a matter of every-day experience that there is a gradual increase of temperature as we descend into the earth's crust. But "whenever a body is hotter at one part than at another, the tendency of heat is always to flow from the hotter part of the body to the colder. Therefore, as the earth's crust is warmer and warmer as we go farther and farther down, there must be a steady flow of heat onwards from the interior to the surface. The earth is therefore even now losing heat at a certain perfectly measurable and calculable rate." This rate has been calculated by Sir William Thomson. Taking the rise of temperature, over the whole earth's surface, "at an average of about one degree for one hundred feet of descent," he concludes "that about ten millions of years ago the surface of the earth had just consolidated, or was just about to consolidate." "Thus we can say at once to geologists," says Professor Tait, "that granting this premiss,—that physical laws have remained as they are now, and that we know of all the physical laws which have been operating since that time,—we cannot give more scope for their speculations than about ten or (say at most) fifteen millions of years.

It is hardly necessary to point out how uncertain are the data on which these calculations are based, and with uncertain data the most rigorous and accurate mathematics can do little. As Professor Huxley has remarked, if we throw peascods into our mathematical mill, we cannot expect to extract wheaten flour. In the first place, the laws of the conduction of heat through *intensely heated* bodies, which are not homogeneous, are by no means well understood, and the earth's crust is, probably, not only heterogeneous in composition, but partially solid and partially liquid. In the second place, the rate of increase of temperature taken 1° for every one hundred feet descent into the earth, though, perhaps, a fair average of known observations, is but a rough generalization. Could we know what is the rate of increase of temperature for every one hundred feet of descent over the vast oceanic areas of our globe, we might have to modify our generalization in a very important degree. I am not aware whether Sir William has, in his estimate, taken into consideration the amount of heat—in all probability great—which has been generated in the earth by contraction of her sphere and the consequent lateral pressure, or the amount which, as suggested by Professor Huxley, may have been produced by chemical combination.

Geologists may, therefore, well hesitate before they accept this limitation to ten or fifteen millions of years. Sir William Thomson himself, however, takes—or until a recent date took—a liberal view of the matter, and granted to geologists about one hundred millions of years.

Sir William Thomson's second argument depends upon tidal retardation. The fact that the tide waves act as a check upon the rotation of the earth on her axis, is now well known. The earth, in fact, revolves within a friction-brake which has caused a slackening of her rate of rotation, even within historical times; for partly from this cause the moon "seems to have been moving quicker as time has gone on since the eclipses of the fifth and eighth centuries before our era." Now this action, if continued long enough, will at length cause the tide waves to remain fixed in their position on the earth's surface, and will cause "the earth constantly to turn the same portion of its surface towards the moon, and therefore to rotate about its axis in the same period as that in which the moon revolves about it. This most remarkable ultimate effect we see already produced in the moon—it is precisely the same thing—we see the moon turning almost exactly the same portion of its surface to the earth at all times."

"It being thus established that the rate of rotation of the earth is constantly becoming slower, the question comes: How long ago must it have solidified in order that it might have the particular amount of polar flattening which it shows at present?" To which Professor Tait gives the somewhat indefinite answer: "That because the earth is so little flattened it must have been rotating at very nearly the same rate as it is now rotating when it became solid. Therefore, as its rate of rotation is undoubtedly becoming slower and slower, it cannot have been many millions of years back when it became solid, else it would have solidified into something very much flatter than we find it. That argument, taken along with the first one, probably reduces the possible period which can be allowed to geologists to something less than ten millions of years."

Now, even if we grant, as is quite probable, that, when it first solidified, the earth was a more oblate spheroid than at present, it is by no means probable that she would have continued to possess the self-same figure until now! Sir William Thomson himself and Mr. George Darwin, in their papers on the possible changes of the earth's axis of rotation, express a belief that the earth would readjust itself to its form of equilibrium, if by some chance it should at any time fail to conform to that figure. This might be effected either "impulsively by means of earthquakes," or gradually, in which latter case there might have been a special tendency for the melted products of volcanic action to be extruded in the neighbourhood of the polar regions; and it is a noteworthy fact that polar lands are remarkably volcanic in their character. No geologist who has studied the contortions of strata in any mountain region could believe that, since its first solidification, the earth's figure had been absolutely unaltered, while many would contend, and with much weight, that whatever its original form, during the mechanical deposition of strata its present figure must have been produced. "We cannot infer from the present shape of our globe," writes Mr. Croll, "what was its form, or the rate at which it was rotating at the time when its crust became solidified. Although it had been as oblate as the planet Jupiter, denudation must in time have given it its present form." Polar ice-caps and the varying distribution of land and ocean introduce uncertainties into the data for calculation, which must prevent our placing any implicit faith in the results obtained.

The third point taken into consideration by Sir William Thomson, in his estimate of the length of geological time, is the probable duration of the sun's heat. There are several theories of the origin and source of solar heat. Among others, as indeed we might expect, is one which accounts for this heat by combustion, such as is carried on when we burn coal in a fire-grate. But "to maintain the present rate of radiation," says Mr. Croll, "it would require the combustion of about 1500 pounds of coal per hour on every square foot of the sun's surface, and were the sun composed of that material, it would be all consumed in less than five thousand years." "The opinion," he adds, "that the sun's heat is maintained by combustion, cannot be entertained for a single moment."

Another hypothesis shall be stated and answered in the words of Professor Tyndall (Heat a Mode of Motion, p. 478): "The sun we know rotates upon his axis once in about twenty-five days; and the notion has been entertained that the friction of the periphery of this wheel against something in surrounding space produces the light and heat. But what forms the brake, and by what agency is it held, while it rubs against the sun? Granting, moreover, the existence of the brake, we can calculate the total amount of heat which the sun could generate by such friction. We know his mass; we know his time of rotation; we know the mechanical equivalent of heat; and from these data we can deduce, with certainty, that the force of rotation, if entirely converted into heat, would cover less than two centuries of emission." The Gravitation Theory is, indeed, the only hypothesis which is generally admitted by physicists, but of that theory there are two forms. One of these, which is known as the Meteoric Theory, was first proposed by Dr. Meyer, of Heilbronn. According to this hypothesis, the sun's heat is maintained by the continual fall upon his surface of meteoric matter, by a constant rain of meteorites. The amount of energy exerted by one pound weight falling upon the sun from an infinite distance would be sufficient to raise, says Mr. Croll, one thousand tons to a height of five and a half miles. "It would project the *Warrior*, fully equipped with guns, stores, and ammunition, over the top of Ben Nevis." "Prodigious as is the energy of a single pound of matter falling into the sun, nevertheless a range of mountains, consisting of a hundred and seventy-six cubic miles of solid rock, falling into the sun, would maintain his heat for only a single second. A mass equal to that of the earth would maintain the heat for only ninety-three years, and a mass equal to that of the sun itself falling into the sun, would afford but thirty-three million years' sun heat." The Meteoric Theory has now given way before that known as the Contraction or Condensation Theory of Helmholtz.

If we take a closed cylinder, in which works a closely-fitting piston, and, by a sudden downward motion of the piston, condense the air within the cylinder, we shall raise the temperature of that air, and this to such an extent, that a piece of German tinder, placed at the bottom of the cylinder, may be ignited in this way. If the pressure were to be brought to bear slowly instead of rapidly, an equal amount of heat would be produced, and if, instead of the external force of muscular energy, the internal force of the gravitation of the particles of the gaseous air towards each other were to cause the condensation, the same effect would be produced: heat would be evolved. According to the Nebular hypothesis, the primitive fire-mist, or nebulous mass, out of which our system has been elaborated, once extended beyond the orbit of the sun's most distant planet. During the condensation from that nebulous state to the present condition of the sun, a definite amount of heat must have been given out by that luminary. This amount has been approximately calculated. It would suffice for the radiation of some *twenty millions* of years, or if, as is probable, the sun's density increases towards its centre, for that of a somewhat longer period. If gravitation, therefore, be the only possible source of sun heat, all geological phenomena will have to be comprised within a period of less than twenty millions of years. But it is highly improbable, as Mr. Croll has pointed out, that the nebulous mass should have existed in the gaseous state, without possessing a high temperature to begin with. Nay, rather, it is most probable that it was to its excessive temperature that its intensely rarefied condition was due. How, then, was this high initial temperature produced? The answer must be a purely hypothetical one. But there is one way in which this temperature may have been produced.

Our system is believed by astronomers to be moving onward through space, probably in the direction of the constellation Hercules, and from analogy we may well presume that other suns are likewise in motion. Sirius, for example, has a relative motion to that of our sun, which tends to increase the distance between these bodies by about twenty miles in every second of time. Other celestial globes must be approaching each other. Taking an hypothetical case, Mr. Croll tells us that, "Two bodies, each one half the mass of the sun, moving directly towards each other with a velocity of four hundred and seventy-six miles per second, would by their concussion generate in a *single moment* fifty million years' heat." "Why may not the sun have been composed of two such bodies?" he adds, "And why may not the original store of heat possessed by him have all been derived from the concussion of these two bodies?" "Two such bodies coming into collision with that velocity would be dissipated into vapour by such an inconceivable amount of heat as would thus be generated; and when they condensed on cooling, they would form one spherical mass like the sun."

Thus, although the consideration of the sun as our source of heat would seem at first to limit the history of the earth, as the habitation of life, to some fifteen or twenty millions of years, a method by which the sun-heat may have sufficed for a hundred million of years is at any rate not inconceivable.

On the other hand, Mr. Norman Lockyer "thinks it likely that many of the substances which we believe to be elements, because we have not been able to decompose them, are really compounds; and that, during the early periods of a star's lifetime, their components existed in an uncombined state, the dissociation being perhaps due to intense heat; when the heat was so far reduced that it was no longer able to keep the elements apart, chemical combination took place, and the process may have set free a very considerable quantity of heat; in other words, when the energy which had before been occupied in preventing combination became no longer equal to the task, it appeared as sensible heat." That the data, on which these speculations concerning solar radiation are conducted, are not of a perfectly certain nature, may be gathered from the following quotation from Professor Tait's sixth lecture: "The very lowest estimate which we can make of the capacity of the sun for heat is such that, cooling at the present rate—losing energy at its present rate—the sun cannot possibly cool more than a single degree Centigrade in seven years. It may be, on the highest estimate we can take, one degree in seven thousand years; the data are very uncertain; but we may say that these are the limits between which it must lie."

Physically speaking, therefore, we may consider that geological time must be comprised within limits of from ten to one hundred millions of years.

Let us now turn to the other side of the question, and consider past time from the geological standpoint. The questions for consideration are obviously these. In the first place, what is the *average* thickness of the sedimentary formations of some definite area, say Great Britain? in the second place, at what rates were they severally and collectively deposited? and lastly, what was the length of time occupied in their deposition?

It is essentially necessary that we should confine our attention to the thickness of the rocks of a definite area. We know next to nothing of the geology of the world taken as a whole. Living as we do on the land, we have only the power of studying at most somewhat less than one-fourth of the earth's surface, and of that one-fourth but a very small portion is actually known to us. Mr. Croll has calculated that, assuming the duration of geological time to be one hundred million years, at the present rate of denudation the total mean thickness of rock formed during that time cannot exceed five thousand feet. This may be so, and Mr. Croll's supposition, that in the depths of the Atlantic, Pacific and Indian Oceans, "little or no stratified deposits may exist," may possibly be true. Our wisest course, however, in the existing state of knowledge, is, as it seems to me, to study our own group of rocks, the conditions under which those rocks were formed, and the evidence which we have, or have not, for long breaks in the continuity of their deposition. This is the task to which I will now apply myself.

Professor Ramsay, Director-General of the Geological Survey of Great Britain, tells us that the sedimentary formations of that area have a *maximum* thickness of upwards of seventy-two thousand feet, (thirteen and a half miles). But to this must be added, say some geologists, "the quantity of rock removed during past ages by denudation." "In many places," writes Mr. Croll, "the missing beds must have been of enormous thickness. The time represented by beds which have disappeared is, doubtless, as already remarked, much greater than that represented by the beds which now remain."

We must be careful, however, not to confuse the maximum thickness given by Professor Ramsay with the average thickness of the strata. In different parts of England the same series of strata will often vary much in thickness. For example, a band of Oolitic rocks runs across England from the coast of Yorkshire to that of Dorsetshire. Near Cheltenham the thickness is more than 500 feet, while in Dorsetshire it is found to be reduced to less than 25 feet! Other instances might be given to any extent. The Kimmeridge Clay near Oxford is some 90 or 100 feet thick; but in the Sub-wealden boring near Hastings it was found to have a thickness of some 700 feet. We may therefore fairly consider that the maximum estimate, seventy-two thousand feet, is considerably in excess of the average thickness of the sedimentary rocks of Great Britain. The argument, too, as to the amount of rock swept away in past times by denudation, must not be pushed too far. In many parts, indeed, whole groups of strata have disappeared from the rocky structure of our island from this cause; but in other parts these groups are well represented. From the fact also that during the elevation of our islands the strata must have been tilted so as to assume an inclined position, denudation has exerted its destructive influence on the edges of the strata, and therefore has not precluded us from estimating their original thickness. It is as if a fire had occurred in our geological library, which did indeed destroy a great mass of literature, but acting upon the exposed edges of the books, left a portion of each in its place, which portion represents the thickness, but not the size of the book.

But there is another fact to be taken into consideration. Professor J. Young (Pres. Address, Sect. C, Brit. Assoc., 1876) has pointed out that our method of arranging the rocks in one long series, from Laurentian to historical times, is erroneous, and leads us to give an excessive estimate of the thickness of our strata. He argues that some groups, which we are wont to arrange in a continuous vertical series, were in reality contemporaneous, and should be arranged side by side in parallel series. Our strata do not furnish us, as is generally taught, with one continuous though mutilated volume, but with two or three contemporaneous and also mutilated volumes, bound up together. Let us consider for a moment the strata now in process of formation in the neighbourhood of our islands. In the English Channel sand is being deposited; further west, in the deeper stiller water south of Ireland, fine mud is being laid down; and somewhat further west, in the deeper Atlantic, *Globigerina* ooze is being formed. Now it can hardly fail to happen that in many places near the boundaries of these deposits fine mud will be laid down on the top of *Globigerina* ooze, on the one hand, and sand on the fine mud, on the other hand. But how erroneous would be the conclusions of the future geologist, who, arguing from the fact that he found in one area the clay lying upon chalk, and in another sand upon the clay, placed these strata in one continuous series, and took the *maximum* thickness of each. In this way he might easily form an estimate at least *double* the true thickness of the formations.

And yet in the tables of strata geologists almost invariably adopt the linear arrangement of strata, and have a tendency to take the maximum thickness of each group of rocks. Thus we group certain rocks as under:

Chalk
Upper Greensand
Gault
Lower Greensand
Wealden
Purbeck.

Professor Young, however, in his Address, thought it highly probable that "the Lower Greensand is contemporaneous with part of the Chalk, so were parts of the Wealden; nay, even of the Purbeck a portion must have been forming while the Cretaceous sea was gradually deepening southward and westward." Our earth's history, indeed, is not like the simple history of one kingdom, but more closely resembles the contemporaneous history of several provinces.

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

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## III.—What must be Explained before the Preservation of Deposits under Till is Explained.

By Professor John Young, M.D., Glasgow University.

As I am one of those who find difficulty in understanding the preservation of stratified deposits beneath the Till, I would like to point out to Mr. J. Geikie that he has not correctly stated the difficulty in his paper (Geol. Mag. Feb. 1878) on "The Preservation of Deposits under Till or Boulder-clay." The difficulty really lies in the explanation of how the Till itself was deposited: were that clear, the preservation of beds beneath it might be at once intelligible. Admitting the passage of an ice-sheet across the country, admitting further that the Till is the *moraine profonde* of such an ice-sheet, the accumulation of 100 feet of Till beneath the ice-sheet is a phenomenon which has not been explained, and cannot be passed over as unimportant. A moving mass of ice, 2000 feet thick, seems a formidable agent of erosion; yet where I now write nearly 100 feet of Till intervene between the surface and the Carboniferous rocks, which, where exposed, shows striations having the usual compass bearing for this neighbourhood. The greater portion of the Till hereabouts is derived from the Carboniferous rocks of the district, but numerous boulders of granite, felstone, schist, and of Old Red Sandstone sedimentary and volcanic rocks, show that the ice had brought materials from a wider area. The limits of the Carboniferous series are about twelve miles to the west and north-west of Glasgow, that being the direction whence the ice came. As the ice of a modern glacier pushes the results of erosion before it, we may conclude that the old ice-sheet with a pressure of about 1000 lbs. to the square inch did the same; indeed, Mr. Geikie has already accepted this "idea as to how an ice-sheet would behave," but without explaining how the alternate exposure and concealment was effected in the presence of very thick Till. It may be said that the ice pushed its *moraine profonde* before it, but then Hugh Miller's "pavements" have always been referred to as proofs that the ice overrode not displaced the Till already accumulated. And this was inferred from the fact that glaciers, when they do override their terminal moraines, grind down their new beds. Professor Geikie has suggested that the upper part of the Till of Scotland may belong to the same series as the inland Till, may indeed have been the product of the same ice-sheet, in which case "they will indicate for us those portions of the great *gründ moräne* which, instead of accumulating on or close to the land, were actually pushed by the advancing ice far out to sea, where they were more or less affected by marine currents, and sometimes received and preserved marine organisms." Even this passage does not give a clear view of how the Till accumulated *on* the land to such depths as I have mentioned; for it must be remembered that Till contains from 50 to 65 per cent. of impalpable mud which, had the *moraine profonde* been accumulated on land, would have been washed away by the waters constantly present beneath moving ice. But the admission that the upper part of the Till might have been laid down in the sea without being wholly rearranged is important. The preparation of a text-book compelled me, four years ago, to record the difficulties which the ice-sheet did not solve, and which I had always pointed out in my lectures. I then suggested as a possibility that the Till, pushed by the advancing ice-sheet off the land, might have gathered on the sea-floor in comparatively undisturbed water, protected by ice, either the land-ice or a mass of ice of greater size and duration than the modern ice-foot. This compromise between land-ice and sea-ice seemed the only possible way of reconciling the thickness of the Till at places with its generally local aspect. Deposits of promiscuous rubbish over stratified material without disturbance of the latter is thus possible, while the crumpling and contortion of the strata in certain places might be the work of bergs or coast-ice, the erosion perhaps due to the subglacier waters. When we are asked to believe that the Till is not merely a product of land-ice, but accumulated on land under a moving ice-sheet, and are further asked to accept the erosion, the contortion and the non-disturbance of stratified beds as alike the accompaniments of the passage, not of land-ice, but of the morainic matter pushed forward by it, we are practically asked to give up the attempt to solve a difficulty which has never been really faced. This was, I assume, not Mr. Geikie's meaning; indeed a foot-note betrays consciousness of the unsatisfactory character of the argument, though the suggestion that the interglacial beds were not eroded by the ice because they were frozen scarcely adds to our knowledge. Mr. Geikie says that the varying, I should call it eccentric behaviour of the ice, is no more a difficulty than the erosion by a river at one point, the deposit of alluvium at another. But this, like all analogies, is a dangerous illustration: the alluvium is thrown out by the river and left. It would indeed be a support if the river laid down thick alluvium and did not erode it: if further the alluvium was derived from the district in which it was laid down. As the major part of what has been written on the "Glacial Epoch" rests on preconceptions and *à priori* anticipations as to what ice would do, I shall not discuss the evidence on which even authoritative statements have been put forth. My wish is to learn how the 100 feet of Till were accumulated: for even if they were piled up under a thinning glacier, it still remains to be explained how so vast a quantity of detritus could have been won from a small area by an agent steadily diminishing in force.

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## IV.—Note on *Penæus Sharpii*, a Macrurous Decapod Crustacean, from the Upper Lias, Kingsthorpe, near Northampton.

By Henry Woodward, LL.D., F.R.S., etc.

(PLATE IV.)

In a paper on the Lias of Ilminster, by my friend Mr. Charles Moore, F.G.S., communicated to the Somerset Natural History Society, and published in their Proceedings (1865–6, vol. xiii. p. 72), I gave a list of the Crustacea submitted to me for examination by Mr. Moore, among which was a species belonging to the genus *Penæus*, referred by me to *P. latipes*, Oppel, from the Upper and Middle Lias of Ilminster.

In my fourth Report "On the Structure and Classification of the Fossil Crustacea," presented to the British Association (Section C. Geology), at the Norwich Meeting, August, 1868, I noticed the occurrence of a second British species belonging to this genus from the Lias of Northamptonshire, and named by me *Penæus Sharpii.*

The following is an extract from my Report, p. 74:—"I have now to notice another species of the genus *Penæus* of Fabricius from the (Lower[1]) Lias of Northampton. This is a remarkably persistent form, and the genus is actually found now living in the Mediterranean if Dr. Oppel's determination be correct, which I feel little doubt in endorsing.[2]

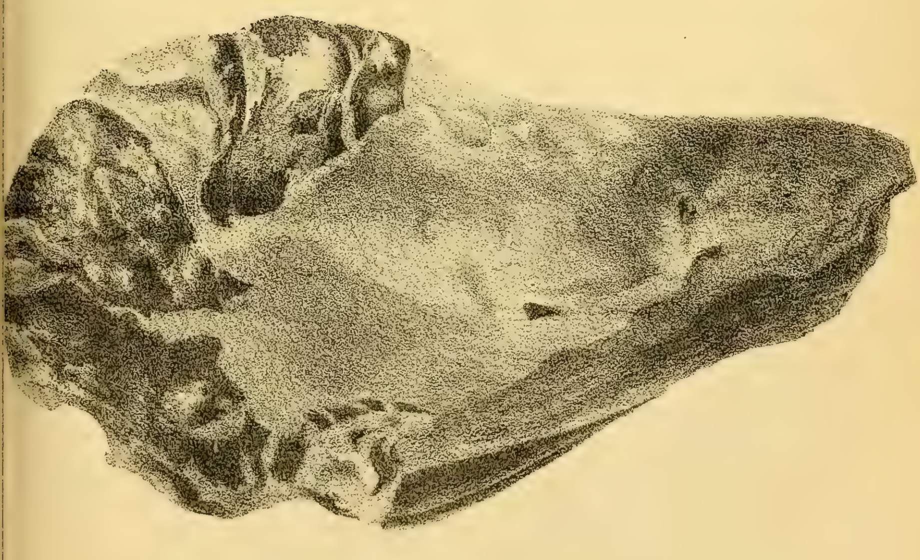
"This handsome Crustacean" (see Plate IV.) "was not less than $9\frac{1}{2}$ inches in length when measured along the dorsal line, the carapace being about 3 inches, and the abdomen $6\frac{1}{2}$; the rostrum was very strongly serrated, as in the *Palæmonidæ*, but the serrations have been abraded in the fossil.

"This form most nearly resembles in size and appearance the *Penæus speciosus* of Münster, but differs slightly in the form of the border of the abdominal segments, and also in the direction of the strong and deeply-forked sulcus which marks each side of the latero-anterior portion of the carapace near the base of the great antennæ. The surface of the carapace and segments was highly enamelled, some portions of which may still be observed in the fossil.

[1] This should be *Upper* Lias.

[2] Dr. Oppel has described five species belonging to the genus *Penæus*. One (*P. Liasicus*) from the Lower Lias of Schambelen and four from the Lithographic Stone of Bavaria.

PENÆUS SHARPII, Woodward.
(UPPER LIAS, Kingsthorpe, Northampton.)



*Elith. Iyes ad. nat. et lap. del.*

"I have named it *Penœus Sharpii,* after Mr. Samuel Sharp, F.S.A., F.G.S., who is the discoverer of the fossil."

My present object in again calling attention to this specimen is to correct an error made in 1868, when I described it as from "the *Lower* Lias"—the fact being, as pointed out by my friend Mr. Sharp, that it occurs in the very top zone of the *Upper* Lias at Kingsthorpe, in a bed in which *Ammonites serpentinus, A. communis,* and *A. bifrons,* are abundant.

This important correction also enables me to avail myself of the two carefully drawn views of *Penœus Sharpii* by my friend Miss Edith Jeyes, to whom I desire to express my best thanks.

The specimen, together with a fine series of Northamptonshire and Lincolnshire Fossils, from Mr. S. Sharp's Museum, now form a part of the National Collection.

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## NOTICES OF MEMOIRS.

"RECHERCHES SUR LES TERRAINS TERTIAIRES DE L'EUROPE MÉRIDIONALE." Par MM. HÉBERT et MUNIER-CHALMAS. (Comptes Rendus des Séances de l'Académie des Sciences. tom. lxxxv.)

A DIFFERENCE of opinion between M. Bayan and M. Hébert with respect to the relative position of the lower Eocene beds of Rouen and San-Giovanni Ilarione, led the latter observer to undertake a personal survey of the district of Vicenza. Accordingly, in company with M. Munier-Chalmas, who carried on the palæontological portion of work, he not only paid a visit to that locality, but extended his observations to the Tertiary beds of Hungary. The results of these researches are embodied in the paper, or rather series of papers, now before us. The authors first visited Hungary, and there, aided by Herr Max von Hantken, the Director of the Hungarian Geological Institute, they made a careful examination of the Tertiary strata. These they describe with some minuteness, and come to the conclusion that the Nummulitic deposits all belong to the Middle and Upper Eocene, are divisible into five well-marked zones, of which four are characterized by different species of Nummulites; whilst the Lower Miocene is represented by two beds, respectively characterized, as in the Paris Basin, by *Cyrena convexa* and *Pectunculus obovatus.*

Proceeding to Vicenza, a parallel series of deposits was made out, which are described with the same exactitude as the others. The volcanic rocks of this district, held by many to be contemporaneous, are considered by the authors to belong to a later period; and the intercalation, so often cited, of basalts with the beds of limestone, they maintain is merely apparent. No notice, therefore, is taken of them.

M. Hébert's opinions concerning the synchronism of these two series of deposits with each other, and those of the Paris Basin, together with the various zones into which they are divided, will be best seen by referring to the table appended to the paper, which is here reproduced for the convenience of our readers. (See p. 166.)

B. B. W.

| FORMATIONS. | DIVISIONS. | VICENZA. | HUNGARY. | PARIS BASIN. |
|---|---|---|---|---|
| MIOCENE. | LOWER. | Castel-Gomberto Limestone, with *Natica crassatina*. | Sands with *Pectunculus obovatus*. | Sables d'Etampes with *Natica crassatina* and *Pectunculus obovatus*. |
| | | Laverda Marls, Tufa of Sangonini, and Salcedo. | Beds with *Cyrena convexa* and *Cerithium margaritaceum*. | Limestone at Brie, and *Cyrena convexa* marls. |
| EOCENE. | UPPER. | 3. Coral-limestones of Crosara.<br>2. Brendola marls and Priabona beds with *Orbitoïdes*, etc.<br>1. Beds with *Cerithium Diaboli*. | 2. Buda marls.<br>1. Bed with Orbitoïdes and *Nummulites Tchihatchefi*. | Gypsum.<br>Saint-Ouen limestones? |
| | MIDDLE. | 6. Ronca limestone, with *Fimbria major*.<br>5. Ronca tufa, with *Cerithium corvinum*. | Beds with *Nummulites striata* and *Cerithium corvinum*. | Sables de Beauchamp.<br>Upper Calcaire grossier. |
| | | 4. San-Giovanni Ilarione limestone, with large Nummulites. | Limestone with *Nummulites perforata*, *N. spira*, and *N. complanata*. | Limestone, with *Turritella imbricataria*, *Fusus scalarinus*, *Cerithium lamellosum*, etc. |
| | | 3. Monte Postale limestone, with *Cerithium gomphoceras*. | Beds with *Nummulites subplanulata*. | Beds with *Nummulites lævigata*. |
| | | 2. Beds with *Alveolinæ*, and fish-beds of Monte-Bolca. | Beds with *Cerithium Bakonicum*. | Wanting. |
| | | 1. Monte-Spilecco limestone, with *Rhynchonella polymorpha*. | Lignites, with *Cyrena grandis*. | |

## REVIEWS.

The Physical Geology and Geography of Ireland. By E. Hull, M.A., F.R.S., Director of the Geological Survey, Ireland, and Professor of Geology in the Royal College of Science, Dublin. Post 8vo. with 2 coloured maps and 26 wood engravings, pp. xvi. and 291. (London: Stanford, 1878.)

*Second Notice.*

(Continued from the March Number, p. 127.)

HAVING thus given his readers an acquaintance with the fundamental structure, or, as it were, the internal anatomy of the country, the author proceeds to discuss the causes of its present features, its mountains and valleys, its rivers and lakes. And first taking up the mountains, he naturally, as a geologist, devotes attention principally to the question of the age of the mountain ranges, that is, the date (geological) of their first birth, not merely of their subsequent development or reproduction. It will be quite unnecessary to explain here any of the steps in this reasoning, but we shall give a summary of the conclusions which he arrives at. The entire surface of Ireland, viewed as a whole, consists physically of a great central plain bounded in most directions, but not entirely surrounded, by groups of mountains. These naturally group themselves into (1) the N.W. Highlands; Donegal and Derry—(2) the Western Highlands; Galway, Mayo, etc.—(3) the S.W. Highlands; Kerry, Cork, with outlying ridges—(4) the S.E. Highlands; Wicklow, Dublin—and (5) the N.E. Highlands; Carlingford, Down, etc. Of these the last mentioned are decidedly the most recent in time of birth, they being decidedly later than the Carboniferous era; but older than Tertiary. The author believes them to be probably Permian. They are old volcanic in origin. Then the S.W. Highlands owe their existence to powerful terrestrial mechanical forces, which have compressed the bedded rocks into enormous folds and curves with a general E. and W. axial direction, their great anticlinals often broken and partly denuded at the top of curve, and giving rise to some of the most elevated ground in Ireland, while the synclinals have been eroded into river-valleys and deep fiords, so well marked in the indentations of the S.W. coast (Bantry, Dunmanus, Kenmare Bays). And these forces were brought into action during the period between the Carboniferous and the Permian. The other three groups, the western, the north-western, and the south-western highlands, were of a date between the Lower and the Upper Silurian (probably 'pre-Llandovery'), and are due to the exertion of intense and widespread metamorphic action. The direction of the axes of these groups is nearly the same, and is between E.N.E. and N.E.

The 'great central plain' next comes under review. This may be roughly considered conterminous with the Carboniferous Limestone, although this limestone itself is only occasionally visible, the greater portion of the surface being covered by beds of Boulder-clay and limestone gravel, or by shallow lakes and sluggish rivers. Extensive peat mosses or bogs cover large areas of this central plain.[1]

In places over this great plain we find still remaining detached hills of Coal-measure rocks, monuments of the former extension of these over the entire area. The probability of the much greater former extent of the Carboniferous rocks is well shown, and a little sketch-map given, which indicates that only detached parts of Donegal, of Galway, and Wicklow were left uncovered originally by one or other of the deposits of that great period. Such being then the original condition of this area, the effects of marine denudation on such a surface are discussed, the existence of such planes, of date even prior to the Carboniferous epoch, pointed out (Slieve Partry), and the grand instances of the general smoothened or planed down surface out of which the bold features of the S.W. of Ireland have since been carved by subaerial action. He then details the features which would result from these successive operations, and concludes, that at the close of this long period of disturbance and denudation, lying between the Carboniferous epoch on the one hand and the Permian on the other, the surface of Ireland would present the appearance of a plain partly formed of Coal-measures, and partly of older rocks, with slight inclinations in various directions in which the streams and rivers would begin to flow, when the whole had been elevated into land. Out of such a gently undulating plain the physical features of Ireland were probably sculptured: the rivers collected and carried off the *débris;* the softer Carboniferous rocks, which offered such favourable conditions for the wasting forces to act upon, began rapidly to disappear; and the purer limestones below, once reached, were quickly dissolved in the rain-fed waters of the streams, leaving the harder Old Red and Silurian rocks standing out in bold ridges, their relative elevation due not so much to any forces of upheaval, as to the comparatively greater destruction and removal of the adjoining strata. To estimate the full power of such forces, we must attempt to form some idea of the time during which they were in operation, and here we must recall the fact already noticed, that in Ireland there is no representative (in the portion occupied by the great central plain of which the author is speaking) whatever of the Mesozoic, or older Cainozoic rocks, and that the only satisfactory cause of this absence, when they are so largely and fully represented in the adjoining island, is that they never were deposited in Ireland, or, in other words, that, during the long period represented by their formation, part of Ireland was above water, and was subjected to all the destroying forces which can only act energetically on dry land. "If this be so," Prof. Hull eloquently says, "how vast was the lapse of time during which this portion of the British Islands was being subjected to the wasting influences of rain, rivers, and other subaerial agents of erosion! During this time the Permian beds, with their varied deposits of sandstone and limestone, stored with marine fossils, were deposited; the great salt lakes of the Triassic period were constructed; successive generations of Saurians, Molluscs, and other marine forms flourished and passed away during the Liassic stage; great beds of Oolitic limestone, now rising into mountain ridges along both sides of the central axis of the Alps, and composed almost entirely of the shells and skeletons of marine organisms, were laid down over the floor of the Jurassic sea. Then followed in succession subaerial, lacustrine and estuarine conditions, which at length gave place to fresh submersions under the ocean of the Cretaceous period, during which masses of limestone, many hundreds of feet in thickness, were constructed by the ceaseless industry of lowly-organized marine animals, chiefly Foraminifera. To these the varied deposits of the Tertiary age were superadded, and over the south of Europe, along a zone extending from the countries bordering the Mediterranean to the frontiers of China, the Nummulite

[1] The wording of the book under review might here give rise to an erroneous idea, which however we do not think the author intends to convey. "He says, "The extensive peat mosses . . . . are a still more recent covering (of the limestone), and generally occupy the positions of former shallow lakes" (p. 157). This would imply that they occur resting immediately on, or forming a direct covering to the limestone—in reality, we believe they never do. They occupy shallow lake-like depressions in the clays, a thin deposit of calcareous marl with fragments of shells marking the lacustrine deposits at their base, before the growth of vegetation converted the pool into a moss, or bog. We believe it scarcely possible for such a peat moss to be formed upon an open and highly porous base, such as the limestone itself would afford.

limestone, the greatest limestone formation in the world, was built up mainly of the coiled shells of a special group of Foraminifera, the Nummulites. Throughout this inconceivably long lapse of time our island was more or less unsubmerged, its surface being swept by subaerial waters, and its strata carried little by little into the adjoining ocean, to form perhaps some of the strata which were being piled up over the ocean bed of the British area."[1]

The origin of the river-valleys next claims attention. And here the views of Jukes, Ramsay, and others are fully endorsed in accounting for the frequent occurrence of such facts as that rivers cut through bold escarpments of hard rock, which, at first sight, would appear certain to have barred the course of the streams. It is thus argued that the course of the river Shannon, the largest river of Ireland (where, for example, it cuts through the high ridges marked on either side by the hills Slieve Bernagh and Slieve Arra, through which gorge it now flows, apparently in preference to taking comparatively much lower ground, and an easier course, to Galway Bay), is really due to the fact that when the river first took this channel, the ground now forming these ridges of mountains was in reality somewhat lower than the ground to the north of it, now part of the plains. And the river, having once commenced cutting out its channel, has never since abandoned that course, but has gone on gradually lowering its valley, till the wide gorge, through which it now foams in its rapids and falls, resulted. Reasoning of a similar kind is applied to the cases of the Blackwater, the Lee, etc.; but here Prof. Hull, most justly as we think, brings in also the consideration of other physical causes, and argues that in such cases, where not only do the rivers cut across ridges of harder rocks, but, to do so, divert their course nearly at right angles to their general direction, there must have been some disturbance at or close to the point of divergence; and in the two cases noticed he appeals to the existence of lines of fault at these localities, which have naturally had a tendency to divert the water-course. We are glad to see this open acknowledgment of the influence of such forces, which have been, we think, too much ignored of late years.

Passing over the notice of some "old dried-up river-valleys," as the author calls some gorges, which have obviously been originally cut out by running water, but which now have only trifling little streams trickling through them, or are dry, we come to the Lakes of Ireland. These are divided into three classes—(1) Lakes of Mechanical origin—(2) Lakes of Glacial origin—(3) Lakes resulting from Chemical solution. These lakes in Ireland are very numerous and extensive, covering a very large area of the country. Pre-eminent among them is Lough Neagh, the largest lake in the British Isles. This Mr. Hardman[2] has shown to be of Post-Miocene age, perhaps Pre-Pliocene, and Mr. Hull adopts the views of this valuable paper. They

[1] We regret that we are compelled to think that Prof. Hull has very seriously injured the effect of this telling paragraph by the concluding sentences. It is so seldom that we find any attempt at what might be called forced oratory or over-strained sentiments in Mr. Hull's matter-of-fact writings, that any departure from good taste in such a direction makes the stronger impression. The danger of using terms and expressions derived from and only applicable to intellectual beings, and their rational acts, in explanation of inorganic forces, has often been insisted on, and has here also proved to be the origin of the pseudo-scientific and false analysis of the writer. It may be perfectly true that part of the material removed from the surface of Ireland was thrown down in the British area, and may so far have contributed to the future mineral wealth of England. But when he speaks of Ireland "stripping herself to clothe her sister," "and to supply materials for protecting from atmospheric waste her vast stores of Coal, upon which her greatness and prosperity now so largely depends;" and even goes on to exclaim "*this debt ought never to be forgotten*"—the writer only excites the smile of geologists and the wondering stare of others. We should not wonder, to carry out the idea further, if some of the modern Home Rulers would threaten to bring an action to recover compensation for the loss incurred by their country (countless ages before man existed at all) by this reckless sacrifice to England; while on the other hand we have little doubt that some of those who are now harassed and vexed by the obstructiveness of modern patriots would be glad to see a little continuance of the former generosity on the part of Ireland towards her poor sister, in these sadly degenerate days!! We cannot too strongly reprobate such mischievous and false attempts at sentimentality in scientific questions.

[2] Geol. Mag. Vol. III. Dec. II. p. 556; Journ. Roy. Geol. Soc. Irel. vol. iv. p. 170.

think the river, which flows into the lake from the South, took its course along the general depression caused by a disturbance of the great Miocene basaltic sheets, and which general depression or bottom of the basin of the volcanic country has been already noticed; and was pent up into a lake by some of the faults, which cross the area of the lake, and some of which have considerable downthrow to the north, corresponding in position with the greatest depth of the lake. This older lake was, as already noticed, of much greater size than the present one—which has gradually retreated, as its barrier was worn down. The lake therefore is considered to be chiefly a basin of submergence formed by the mechanical action of faults in the strata forming its bed. Although it is said that this origin of Lough Neagh is 'wholly exceptional' (p. 198), Lough Allen seems, according to the author's views, to be due to very similar causes. This noble lake forms a great reservoir for the head-waters of the Shannon. It fills a wide valley, the banks of which are formed of the Yoredale rocks and the floor of Carboniferous Limestone, and the formation of the lake is attributed to the production of a barrier across its lower end by a large fault, heading E. 20° N., with a downthrow to the north. This fault brings the Carboniferous Limestone on that side down against the Silurian and Old Red rocks, and has thus had precisely the same effect which an artificially raised barrier would have in converting the river-valley above into a lake. This barrier has been considerably worn down and lowered since its formation, but it still retains a relative elevation as compared with the floor of the lake, and so, of course, the lake remains. There is no distinct evidence of the age of this faulting, but the author points out that its direction is very similar to the direction of the faults which have, as stated, produced Lough Neagh. And he thinks it not improbable that it was really produced about the same epoch—that is, between the Miocene and Pliocene.

With regard to lakes of Glacial origin, there are said to be two ways in which these forces have acted: 1. by actually scooping out rock-basins, and 2. by depositing moraines, heaped up across a valley or hollow, and thus pending up the waters of the stream flowing along the depression above. Of both these varieties numerous instances occur in Ireland, though none of any great size. In places they form regular networks of little loughlets and rock-basins. The author also thinks that the wide shallow lakes of the central plain of Ireland owe much of their extent and form to the action of ice, although they are principally due to another cause. After giving several well-marked cases of moraine-dammed lakes (Lough Bray, Lough Nahanagan, etc.), he passes to lakes of Chemical origin. To enumerate all the lakes of the great central plains of Ireland would be a useless waste of space. All have one common character, they are all irregular hollows and depressions in the general limestone floor, now filled with water, and these depressions and hollows are principally due to the solvent action of the water on the limestone rapidly eating into it, and removing it in solution. Some of these lakes are intimately connected with large underground rivers, the channels of which have been in a similar way dissolved out of the limestone. These give rise to lakes and fountains, the true source of which is often not traceable at first. Similar forces of solution and denudation have in many cases produced the deep indentations which abound round the coasts of Ireland, in the limestone districts, and which, subsequently filled with glaciers and scored, and scooped out, passed into the state of "fiords."

The third part of Prof. Hull's work is devoted to the "Glaciation of Ireland." And here we would first direct attention to the very effective and well-executed little map of the "General Glaciation" which is given. It is an admirable example of how much can be compressed into a small space with perfect legibility and clearness. Starting with the assumption that it has been generally recognized that the surface of the solid rocks of Ireland is widely and extensively glaciated, and that an "ice-sheet" covered the greater portion of the country, Prof. Hull bears willing and just testimony to the value of the labours of the Rev. Maxwell Close, and proceeds to discuss the essential differences between General glaciation and Local glaciation, one being antecedent to the other, and of much wider extent. Then adopting this division of the subject, he notices each separately, both being said to "have left their traces on the rock-surfaces in the form of polished and moulded bosses, scars, delicate chisellings, or deep groovings often intersecting each other at various angles, and requiring care and some amount of general knowledge of their causes, in order to distinguish to which period of glaciation they belong" (p. 212). Mapping out the lines of scoring at the bottom of the Lower Boulder-clay has determined the general nature of the ice-movement, and has shown, as our author believes, that it "belongs to one grand dominant system of central pressure, which has caused the ice to move outwards in all directions from a central snow-field towards the existing coasts, except where impeded or deflected by local mountain barriers." After pointing out the reasons for admitting that such markings were caused by ice-borne materials, and the several indications afforded by polished rocks, 'crag and tail' forms, boulders, and their positions, of which numerous instances are given,[1] he proceeds to discuss the laws regulating the movements of this great ice-sheet, "of the existence of which there can be no doubt whatever." He points out, and adopts entirely the conclusions of Mr. Close, that the movements of this ice-sheet have proceeded in opposite directions seawards, from a line or tract of country, stretching in a belt across the island, occupying the country between Lough Corrib and Lough Mask on the west and Lough Neagh on the east, thus stretching for a distance of more than one hundred miles from W.S.W. to E.N.E., from which tract, as from an axis of motion, the ice has passed both north and south. The position of this supposed axis is well shown on the little glaciation map to which we referred, This very remarkable conclusion of Mr. Close is particularly noticed as differing from what is already known in any part of the world with which we are acquainted. In every other known case of such distribution of glacial motion from an axis or centre, those centres have been districts of greater elevation than the country adjoining. The Alps, the Pyrenees, the great elevated Scandinavian highlands, the Snowdon range in Wales, the Cumberland and Westmoreland ranges in England, the Grampians and the Southern highlands in Scotland, are all well-known instances of this. But in Ireland no part of the axis of movement is more than 400, or at the outside 500 feet, above the sea-level, while it is stated, as a positive and admitted fact, that from this an ice-sheet has been set in motion, which has not only topped and completely passed over such little minor obstacles, as, for example, the Coal-fields of Castlecomer, etc., which rise to 700 feet, but has overrun hills of more than 1000, or even 1500 feet, and has been forced up the flanks of higher mountains to still greater elevations. It is, therefore, only right that the propounders of such a theory should endeavour to explain the actions which took place. Mr. Close suggested that the country had been more elevated over the land now occupied by the counties of Mayo and Roscommon than more to the south and east. But Prof. Hull rejects this as quite an insufficient cause, inasmuch as the movement has not taken place merely from a central point, or from the western end of the axis alone, but along a line of more than 100 miles. And he has no hesitation in suggesting at once a different explanation. He says (p. 229), "Is it not conceivable that the line of country here described was at the earliest glacial period the region of greatest snowfall—the region of greatest precipitation of snow, as it is now that of greatest precipitation of rain?"[2] He supposes that the snows were piled up over this belt of country to an 'enormous' depth, and to a less extent over the tracts lying to the south and east, until the vertical pressure of 'thousands of feet' of snow and ice there accumulated was converted into a lateral pressure, forcing the ice to move in a direction towards the points where it could find an outlet. After expressing his confident belief that the vertical pressure of this 'enormous' pile of ice and snow gave the first initial movement to the ice-sheet, both southwards and westwards, Prof. Hull still confesses that we are obliged to have recourse to other modes of explanation of the facts that this motion has been propagated to upwards of one hundred miles from its source, and that it has caused the ice to move, not only over plains, but up the sides of opposing hills and ridges. And to this end he is disposed to adopt a development of Charpentier's dilatation theory, as explained by Dr. Croll. This, in general, is, that the internal pressure resulting from the solidifying of the fluid particles of water which has filled the interstices of the ice, acts on the mass as an expanding force tending to cause the glacier to widen out laterally in all directions, and the author adds—"to move with a linear motion in the line of least resistance," but he does not attempt to show that the direction of motion of the ice-

[1] We do not observe any notice, among the detailed descriptions of the drift deposits of Ireland, of the important fact of the occurrence of pieces of the compact Cretaceous limestone of the N.E. of Ireland in the clays of the South of Ireland, even so far south as the County of Cork.

[2] The writer adds most naively in a note, "Of this, however, I have no positive proof," no general returns of rainfall being available, but he says, "I have little doubt that it is the case."

sheet, as supposed to be proved by the scorings, etc., would be that line of least resistance. A large mass of details of these scorings is given, filling more than twenty pages—but these the student must consult for himself. The thickness of the great ice-sheet is held to have been at least 1000 feet, probably much more.

The existence of local centres for glaciers towards the close of the glacial period, after the submergence of the plains and the general re-emergence of the land again, is then noted and some details given; and the volume then concludes with a very brief chapter "connecting the pre-human with the present age," a chapter which in future editions we hope to see vastly extended.

In reviewing the author's conclusions as a whole, there are only a few points which appear to call for any special notice. One of these is the much greater prominence which Mr. Hull has given to the agency of chemical solution, in the production of physical results, than has been generally acceded to it. In a country where limestone originally formed such a very large portion of the exposed surface, it was only natural to find evidence on a great scale of this action, and we gladly direct attention to the valuable observations of the author on this point. In another direction also, that is, in the fuller application of the effects of terrestrial disturbances as causes of the present physical features of the country, we think the author's views worthy of commendation. There has been of late years too great a tendency to push to extremes the application of some pet theories, till almost the very existence of other forces has been ignored—and we are glad, therefore, to see the influence of faults, and of deepseated disturbances, again appealed to, and restored to its legitimate position in the sequence of formative causes. The wide application of ice forces in their varied exhibition was of course to be expected. The pages of this journal for years have been so filled with valuable and detailed contributions to these inquiries, that our readers are fully prepared to admit the importance of this branch of geological research, and to accept many of the conclusions which have been adopted. But, at the same time, the very nature of many of these contributions to which we have referred suggests to every sound thinker, as we believe, the necessity for great caution and watchfulness before admitting any new hypothesis, however boldly or dogmatically it may be propounded, either as a speculation, or possibly, even, as a fact; for there are many cases in which this, too, has been done. In the analysis of the author's views which we gave above, we have endeavoured to state them with clearness and sufficient fullness to make them intelligible, preferring to leave them for the most part as the opinions of the writer only, and not to discuss them as geological views or doctrines. But we would not be justified in altogether passing over in this way some of these views. With reference to the "General Glaciation of Ireland," a conclusion worked out by the Rev. M. Close, as to the axis or origin of motion of the ice-sheet over the island at the earlier part of the great glacial period, is unhesitatingly adopted by our author; and he proceeds at once to propound—and in terms which lead his reader to suppose that the whole thing was obvious to the smallest consideration—a solution of this anomaly. He supposes that snow and ice were heaped up over a belt of low ground extending more than 100 miles in length, and, say, ten in breadth—to an 'enormous' extent, 'thousands of feet' in depth, etc., so as to give the pressure which he thinks needful to have originated this general outward motion in both opposite directions from this axis. We should greatly have wished that he had given us some idea of the actual physics of such a heap of snow, 'thousands of feet' in depth, perfectly unsupported on either side by any more solid materials—or had shown the probability even of this extreme accumulation which he supposes to have taken place over this belt of country, ever amounting to such a differential excess as to give him the required depth of ice.[1]

But is this idea of Mr. Close's so thoroughly established that we are driven to the region of wild fancy to attempt an explanation of it? An immense mass of detail is referred to by Prof. Hull in evidence of this supposed movement of the ice-sheet (pp. 236-259), but all this evidence must be carefully analysed before we can admit its conclusiveness. And the author must permit us to doubt, and to doubt very seriously, if a great part of it is applicable to the point at issue at all. He himself, and equally every other writer of these glacial theories, insists on the necessity for 'experience,' and a certain knowledge of the causes of these markings, scorings, polishings, etc., appealed to as evidence of the movement, before the observer can appreciate their force or value. And firstly it is urged that in such matters we should take our lessons from the existing centres of glacial action, such as the Alps, Norway, and Greenland. How far has this been done? How many of the dozens of observers, whose notes have been culled, have studied these glacial phenomena in their existing centres? How many have been capable of distinguishing, or have attempted to distinguish,—or have even known the necessity of such an attempt,—marks of local glaciation from those due to the supposed general movement? And if the whole mass of evidence adduced be subjected to such a searching analysis, how far will this idea of a linear axis of motion remain established? We confess we hesitate much before we can admit it. Our author himself adds greatly to our feeling of the necessity for great caution in such matters. In this way (at p. 115), speaking of "River Terraces," the most recent of the "Drift" deposits, he says:—

"Of these the most remarkable and interesting from its historical and architectural associations is the terrace at the lower end of Glendalough, at its confluence with the vale of Glendasan, upon which stands the Round Tower, and the Church of St. Kevin. This terrace is composed of stratified gravel of rounded pebbles and sand banked up against an old moraine which has been thrown across the valley. The upper surface is level and it rises about twenty feet above the bed of the Glenealo River."

Now if we turn to p. 197, we find that—

"After careful examination I have also come to the conclusion that the Round Tower and Churches of Glendalough are built on a moraine, which has been thrown

[1] Old Procopius held that on the tops of high mountains there never fell either snow or rain, because they are above the highest clouds!! Bacon, in one of his wonderfully sententious passages, says, "Adulterina res est in scientiis præcocem esse et promptum, nisi etiam solidus sis et multipliciter instructus."—*De Augm. Scient.*, lib. v. cap. v.

across the Glendalough valley by the glacier that descended the vale of Glendasan. This moraine had originally pent up the waters of the lakes, and against its northern flank the old terrace of gravel (described in another page) has been deposited. Afterwards the river cut down its channel and lowered the level of the waters. In this view Professor Ramsay concurs."

Here the question naturally occurs—Is the Round Tower and are the "Seven Churches" at Glendalough really built on a moraine, or on a river terrace? Nothing is more probable than that a terrace—not however a river-terrace—should have been deposited against the flank of a moraine damming up a lake. But this is not the point here. If in so accessible, and so easily examined and well-marked a locality as Glendalough, it required careful re-examination, and the aid of Prof. Ramsay, to find out that the foundation of the Round Tower was placed, not on a river-terrace, nor even on a terrace, but on a moraine (the two being of totally different ages, and due to totally different causes), we are compelled to think that there must still hang a thick mist of doubt and uncertainty over very many of the thousands of observations of glaciation phenomena which have been recorded. Nor is it within the just limits of expectation to hope that we shall find every one as open to conviction, and as ready to acknowledge error, as Prof. Hull has shown himself to be. Until, however, these doubts be removed, we can have no *knowledge* of the facts—for, as the Stagyrite says, "knowledge is the solution of doubts."

We have felt the want ourselves, and, therefore, do not hesitate to notice it, as it possibly may be supplied in future editions, of a little more aid to the imagination of the reader, by appeals to his eye. The general features and scenery of parts of Ireland are familiar enough to many, but even of those who know such scenery in detail, how few have realized the general character of the outline, or its essential dependence on the structure of the rocks below. Geologists will remember gratefully the vast aid which they derived in framing a general conception of the S.E. of Ireland from the admirable panoramic sketches of Weaver (Trans. Geol. Soc. Lond. 1st series, vol. v.). But we would refer to far more recent, and far less costly, illustrations of this kind in the many valuable publications of the Geological Survey of the United States Territories under Prof. Hayden. Some of these, though almost pure outline, convey the most wonderfully clear and accurate idea of the structure of the country represented, and of the intimate dependence of its physical features on that structure. And if a few such general outlines of the more marked centres of interest in Irish scenery and Irish geology could be given, we have no hesitation in thinking that the book would commend itself to a far wider circle of readers than it is likely at present to command.

The British Association meet in the capital of Ireland in the coming autumn, and there is every prospect that a large concourse of visitors will then be attracted in addition to the ordinary crowd of visitors. The well-known and generally appreciated hospitalities of Dublin, the loveliness of the scenery of the country, and the facilities afforded for numerous excursions, will all offer inducements to the hundreds of strangers who will then visit the "Land of the Giant Deer, and the Giant's Causeway." And to each and every one of these we would say, Make yourself acquainted with the facts detailed in Prof. Hull's "Physical Geology and Geography of Ireland," and so well acquainted that you can realize those facts, and be able to trace the broad features in the succession of events which have produced the present features of the country. Then, whether you tarry in pleasant dalliance over the lovely scenery of Killiney and Bray, or stray in softened mood among the richly wooded beauty of the Dargle or Ovoca, or seek the wilder loneliness of some of the more distant glens of Wicklow or Galway, and stand awestruck and silent before the deeper secrets of Nature's revealing, or whether you visit "that most delightful spot in the British Isles," and contrast the luxuriant fertility and astounding richness of colouring of the lakes and islets and woods of Killarney with the weird savageness of the Gap of Dunloe, or the lonely gloom of the Black Valley, you will derive a deeper and a more lasting impression of the beauties of all, if you bring to this examination a previous acquaintance with the general causes of all the varied features of the country, and with the history of the successive steps in their production. And, in this view, we confidently hope that Prof. Hull's excellent summary will prove remarkably well timed and successful.

## REPORTS AND PROCEEDINGS.

Geological Society of London.—I.—February 6, 1878.—Prof. P. M. Duncan, M.B., F.R.S., President, in the Chair.—The following communications were read :—

1. "On some Foraminifera from Pleistocene Beds in Ischia." By M. Ernest Vanden Broeck. Preceded by some geological remarks by A. W. Waters, Esq., F.G.S.

In this note Mr. Waters referred to certain fossiliferous deposits occurring at various elevations in the island of Ischia, the oldest being a clay found up to 1800 feet on Monte Buceto, whilst the others may be classed with raised beaches. These deposits have been already noticed by Sir Charles Lyell, who obtained from them twenty-eight species of shells, all, with one exception, identified by Deshayes with recent species. M. Fonseca has given a list of ten species of shells from the Buceto beds, and to these Mr. Waters has added ten more, all now living in the neighbouring sea. A portion of marl forming the matrix of one of these shells was sent by Mr. Waters to M. Vanden Broeck, who found in it twenty-seven species of Foraminifera, with respect to which he remarks that this fauna has a more recent facies than that of the true Subapennine deposits, all the species being now living either in the North Atlantic or Arctic Ocean, and nearly all in the Mediterranean. The presence of *Lagenæ* and of some other forms, however, indicates closer relations with the northern oceanic fauna than with that of the warmer Mediterranean. The Foraminifera from Ischia are generally of small size, probably indicating unfavourable conditions. The deposit containing them was probably formed in not very deep water, and more recent than the true Subapennine deposits; and the small size of most of the specimens, and the predominance of northern forms, would seem to show that the deposit took place when the refrigerating influence of the glaciers was beginning to be felt.

2. "On the Influence of the Advent of a Higher Form of Life in modifying the structure of an older and lower Form." By Professor Owen, C.B., F.R.S., F.G.S.

In this paper the author, after referring to the general question of the modification of the structure of organic forms produced by the action of external influences, indicated that, in connexion with this, changes in the nature of the prey of carnivorous animals ought to be taken into consideration. He inferred that cold-blooded aquatic animals formed a much greater proportion of the food of Mesozoic than of Neozoic Crocodiles, and pointed out as connected therewith the well-marked distinction between the amphicœlian and procœlian type of vertebræ respectively characteristic of the two groups. The procœlian character of the trunk-vertebræ better adapts that part of the body to be sustained and moved in air, and may be connected with the incoming in Tertiary times of mammalian prey inducing the Crocodiles to rush on shore. The Mesozoic Crocodiles were encased in a much stronger and more complete dermal armour than their successors, doubtless for their protection from the great Ichthyosaurs, Pliosaurs, etc., which coexisted with them; but as these passed away at the close of the Secondary epoch, the armour of the procœlian Crocodiles has become more scanty, and the diminution of weight and rigidity thus caused would favour progression in air, and the rapidity of movement required for capturing mammalian prey on land. The difference in the position of the palato-nares, and in other related gular and palatal structures, between the Mesozoic and Neozoic Crocodiles, is apparently connected with the power possessed by the latter of holding submerged a powerful mammal without permitting the access of water to the posterior nostrils and windpipe of the Crocodile; and hence the author is inclined to ascribe a fish-diet even to those massive-jawed Crocodiles from the Purbeck (such as *Goniopholis crassidens* and *simus*), which in some respects might seem fitted to grapple with large and active mammals. The small size of the upper temporal apertures in Tertiary and existing Crocodiles is regarded by the author as a further proof in the same direction; these apertures are reduced by the progressive increase of the osseous roof of the temporal vacuities, which again is correlated with increase in the bulk and power of the temporal muscles, the main agents in biting and holding. The differences in the length and strength of the jaw, as a rule, testify in the same direction. Further, the fore-limbs in Mesozoic Crocodiles are shorter than in Neozoic species, indicating that the former were more strictly aquatic in their habits; the fore-limbs in all Crocodiles being closely applied to the body during rapid swimming, and small limbs being less obstructive than larger ones. On the other hand, they would be less efficient as a means of progression on land, and hence it may be inferred that the advent in Tertiary times of mammals frequenting the water-side, tempting the Crocodiles to make a rush upon the land to seize such passing prey, would lead to such strenuous action of the fore-limbs as would account for the increased size and power of those organs in the Neozoic species. The author concluded with some remarks upon the influence of the above considerations upon our views as to the generic divisions of Crocodiles.

3. "Notes on a Crocodilian Jaw from the Coral Rag of Weymouth." By E. Tully Newton, Esq., F.G.S., of H.M. Geological Survey.

In this paper the author described what he believes to be a fragment of the lower jaw of a Crocodilian, obtained from a greyish brown sandy grit, probably belonging to bed 3 of Messrs. Blake and Hudleston's Sandford-Castle section. The specimen measures about 11 inches long, and includes portions of both rami. The right ramus contains the remains of 12 alveoli, some of which, notably the first, second, fourth, and fifth, contain fragments of teeth, which appear to have been directed very obliquely outwards and forwards. The portion of the left ramus preserved gives indications of 14 or 15 teeth. An impression of a tooth in the matrix gives a length of $1\frac{1}{4}$ inch for the crown of the larger teeth; their section was nearly round; but a young unused tooth is slightly compressed, with a distinct ridge running down each side and two smaller ridges on the inner surface. The general surface of the crown was covered with fine but distinct longitudinal ridges. The median area has a spindle-shaped portion separated from the rest by deep grooves, the surface of which is longitudinally grooved; and this character, according to the author, does not occur in either of the genera mentioned by M. Deslongchamps.

4. "Note on Two Skulls from the Wealden and Purbeck Formations indicating a new Subgroup of Crocodilia." By J. W. Hulke, Esq., F.R.S., F.G.S.

The author described a Crocodilian skull obtained by Mr. H. Willett, F.G.S., from the Hastings Sands near Cuckfield, in Sussex, and identified by that gentleman with *Goniopholis crassidens*, Owen; and another from the Purbecks near Swanage, in the collection of the British Museum; which he further compared with a third specimen from Brook, in the Isle of Wight. He had little doubt that Mr. Willett's specimen had been correctly identified, and thought it and the Brook skull were probably specifically identical. All these skulls belong to a group intermediate between the Mesosuchia and Eusuchia of Prof. Huxley. In the constitution and position of the palato-nares they most nearly resemble *Metriorhynchus Blainvillii*, Desl., among the Mesosuchia. The general contour of the skull resembles that prevalent in the typical Crocodiles, such as *Crocodilus rhombifer*. In the arrest of the nasal bones short of the anterior nares they rather resemble *Gavialis*, and still more the Bornean *Rhynchosuchus Schegelii*, as also in the form of the palato-nares. From the combination of characters presented by these Crocodiles (which the author regards as representing two species of *Goniopholis*) and their geological age, the author proposes to place them in an intermediate subgroup, which may be designated Meta-Mesosuchia.

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II.—Annual General Meeting.—February 15th, 1878.—Prof. P. Martin Duncan, M.B., F.R.S., President, in the Chair.

The Secretaries read the Reports of the Council and of the Library and Museum Committee for the year 1877. The Society was described as in an exceedingly prosperous condition, and the income of the year was stated to have considerably exceeded the expenditure. The number of Fellows elected was fully up to the average. The Report further announced the receipt of a bequest of £500 under the will of the late C. Lambert, Esq., which sum, with £150 of the surplus of income, had been invested in Consols for the benefit of the Society.

In presenting the Wollaston Gold Medal to Dr. Thomas Wright, F.R.S., F.G.S., the President addressed him as follows:—

Dr. Wright,—It gives me very great pleasure to present this Medal to you, and to know that your name will be enrolled amongst those of the many distinguished men who, like yourself, have earned this distinction by long and successful labour in geological science. Your careful palæontological work amongst the Echinodermata of the Secondary rocks of England has been as interesting and important to those palæontologists who have followed you in the study, as your description of the Maltese Echinoidea. You have not only collected, but have described carefully some of the most important Mesozoic corals, and have clearly distinguished the succession of some local coral reefs in the British area. Your stratigraphical labours amongst the Rhætic, Jurassic, and Oolitic formations have led to excellent results. Your classification of the great groups of Echinoidea has stood the test of time, and is still employed; and the description and analysis of the species, illustrated so exquisitely, in the volumes of the Palæontographical Society, are models of terse exactitude. Your determination of the correct relation of the madreporic body to the antero-posterior axis of the Echinoid has been accepted by nearly every naturalist, and its bearing on the elucidation of the meaning of the apical system of the Salenidæ is of much importance. The Council considers that your industry and the excellent results of your study establish your claim to this Medal, and I hope that its reception will not only stimulate you to further research, but will reward you for the sacrifices that every man who combines a scientific and a professional career has to suffer.

Dr. Wright, in reply, said:—Mr. President,—I am deeply sensible of the very great honour the Council of the Geological Society has conferred in awarding me the Wollaston Medal, and I beg to return my most heartfelt thanks for their appreciation of my humble labours in palæontological studies. To be enrolled in the list of eminent men on whom this great distinction has been conferred is a position of which the most ambitious may well be proud, whilst the graceful and eulogistic phrases with which you, Mr. President, have conveyed the award, and the friendly greeting I have received from Fellows assembled here to-day, have all touched me exceedingly, and I can find no language adequate to express the sentiments of gratitude I experience on this occasion. It is at all times a pleasure to receive from our contemporaries working on the same line with ourselves a friendly estimate of our honest endeavours, but when the Council of this great Society, which counts among its Members some of the most learned masters of Geological Science, bestows its highest award as an acknowledgment of the worth of my scientific work, I confess how much indeed I appreciate the distinction, and how highly I value the prize.

You have kindly informed me that the Wollaston Medal has been awarded as a recognition of my detailed researches, continued through many years, on the structure, classification, and distribution of the fossil Echinodermata, published by the Palæontographical Society, and for other memoirs on the Jurassic and Tertiary strata of England. If my life is spared, the event of to-day will become a stimulus to renewed exertion in that path of scientific study in which I have plodded for the last thirty years. As much of that work has been carried out by the Palæontographical Society, perhaps you may allow me to say how much I consider the progress of Geology has been advanced by the splendidly illustrated volumes it has published. They form, indeed, a magnificent monument of unpaid voluntary effort in the cause of Science.

Let us never forget that much of the knowledge we have acquired in our researches concerning the mineral structure of the earth is due to Palæontology, and that the future of Geology will largely depend on its onward progress. The accurate description of organic forms, their true position in time, and distribution in space is the important province of Palæontology to determine; and by correctly translating the archæology of organic nature into the pages of geological literature, the palæontologist may hope to solve some of the great questions that distract the naturalists of our day, and enable them to read aright the changing conditions under which life existed during vast periods of past time.

The President then presented the balance of the proceeds of the Wollaston Donation Fund to Mr. W. J. Sollas, M.A., F.G.S., and addressed him as follows:—

Mr. Sollas,—I have great pleasure in handing you the Balance of the proceeds of the Wollaston Donation Fund in recognition of your careful morphological and mineralogical studies upon the fossil Spongida. The Council of this Society is impressed with the belief that you will continue to benefit palæontological science by your researches in those Amorphozoa which, up to a recent date, were comparatively unknown, or whose anatomical characters were misunderstood. Having made an excellent beginning, of a great course of investigation, you will, I trust, be stimulated to perseverance and exactitude by this testimony of the good wishes of this Society.

Mr. Sollas replied:—Mr. President,—I beg to express my thanks to the Council for their award, and to you, Sir, for the encouraging words with which it has been accompanied. Next to the pleasure of discovering something new, and of adding something to the common store of knowledge, I can conceive of no greater gratification than the appreciation of one's fellow-workers, and the approbation of those whom I am proud to regard as my masters and teachers in Science. The study of the fossil sponges presents us with a true El Dorado of research, to which the way has been clearly opened by the labours of those distinguished spongiologists Bowerbank, Oscar Schmidt, and, lastly, Carter, of whom I hope I may be allowed to say that he is *facile princeps*. It will now be my duty, as it is my pleasure, to attempt to make use of this "way," to apply the facts which have been discovered concerning the structure of the living sponges to the interpretation of the sponges of the past, and I trust that in this endeavour I may meet with such a measure of success as shall prove that I have not been an unworthy recipient of the confidence reposed in me to-day.

The President next handed the Murchison Medal to Mr. Warington W. Smyth for transmission to Dr. Hanns Bruno Geinitz, of Dresden, and spoke as follows:—

Mr. Warington Smyth,—The Council of the Geological Society has awarded the Murchison Medal to Dr. Hanns Bruno Geinitz, Professor of Geology in the University of Dresden, for his researches in the geology and palæontology of the Palæozoic and Cretaceous formations of Saxony. For forty years at least Dr. Geinitz has been an assiduous cultivator and promoter of Geological Science. He has especially devoted his attention to the study of the Permian formation, and has greatly increased our knowledge of its fauna and flora. The general differences of the Permian and Carboniferous floras have been pointed out by him in his work on the Permian plants of Saxony. His first essay on the Zechstein was in 1838, and subsequently he wrote on the "Grauwacke formation," which included the Silurian, Devonian, and Carboniferous strata of Saxony. The Cretaceous formation of the same country also received his attention. A friend of, and co-worker with the donor of this Medal, he not only assisted him in his labours, but was occasionally his companion whilst investigating the more interesting localities around Dresden, services which are acknowledged in the work on "Siluria." Dr. Geinitz has contributed many other important works to our science than those which the Council consider to be the most meritorious, and it therefore is a privilege that I should be able to ask you to convey to our old and much esteemed Foreign Member this Medal, which, I am sure, he will appreciate.

Mr. W. W. Smith replied:—I have much satisfaction in receiving from the hands of the President for transmission to Prof. Geinitz the Medal awarded to one who has done so much to advance our knowledge of Central Germany. I have received a letter from the Dresden Professor, in which he states that he is deeply touched at being in this way again associated with the name of his old and venerated friend Sir Roderick Murchison, that he regrets being unable to attend this meeting, but begs to assure the Society of his high appreciation of the honour, and of his intention to consider it a spur to urge him on to fresh work in the same path.

In presenting the balance of the proceeds of the Murchison Geological Fund to Mr. H. Hicks, F.G.S., for transmission to Mr. Charles Lapworth, F.G.S., the President said:—Mr. Hicks,—The Society has lately had the benefit of receiving a most important communication from Mr. Lapworth upon the Silurian rocks of the South of Scotland, and the Graptolites contained in them. This work has been the result of many years' successful labour; and in recognition of its merits, and with the desire of stimulating its author to further investigation, the Council has made this award, which I will request you to convey to him.

Mr. Hicks, in reply, expressed his high appreciation of the value of the work done by Mr Lapworth among the Silurian rocks of Scotland, and the satisfaction that it gave him to be selected as the medium through which an award so well merited was to be conveyed to Mr. Lapworth, from whom he read the following letter: –

"Mr. President and Gentlemen,—Permit me to express my grateful acknowledgment of the honour you have conferred upon me by the award of the Murchison Fund. It is, indeed, a matter of the most profound gratification to myself that what little I have already accomplished has been regarded as meriting this valued distinction. Were any incentive needed beyond the pleasure which ever accompanies the diligent prosecution of original research to animate me to continued exertions in my endeavours to aid, in some degree, in determining the perfect order of nature among the rocks and fossils of the grandest of the geologic formations in the native country of its illustrious founder, it would suffice for me to recollect that the Trustees of his bounty deem these labours worthy of substantial encouragement, and to feel assured therein of the sympathy and approval of the Fellows of the Geological Society of London.—Charles Lapworth, 4, Kinburn Place, St. Andrews, February 12, 1878."

The President next handed to Mr. J. W. Hulke, F.R.S., F.G.S., the Lyell Medal and part of the Lyell Fund for transmission to George Busk, Esq., F.R.S., F.G.S., and addressed him as follows:—

Mr. Hulke,—The public duties of Mr. Busk prevent his receiving this token of the Council's appreciation of his merits as a palæontologist; and in asking you to forward this Medal and Fund to him, I am glad to express my personal gratification in being able to present an award, through you, to so distinguished a scientific man.

The Council and this Society are under great obligations to Mr. Busk, not only for his long series of contributions to science on the fossil Polyzoa and extinct Mammalia, but also for his having very constantly given most careful and conscientious advice upon the value of communications. In giving this award to Mr. Busk I trust that you will remind him that, although he has been awarded the Lyell Medal for those researches which appear to the Council to be the most important in relation to the science of geology, his great industry and careful method of study have enabled him to advance our science in many subjects which refer to the antiquity of man and the Quaternary cave- and gravel-faunas. The examination of the spoils of Brixham cave and of the bones of the breccias of Gibraltar have been published by him, and the results are lasting proofs of the ability of an accomplished and cautious naturalist. Moreover, Mr. Busk, whilst studying the fossil Polyzoa, investigated the recent forms, and his descriptions and classifications are those which are the most followed. In his numerous researches, whether they relate to biology or to palæontology, the inductive method has always been followed; and as in connexion with the study of the fossil forms, he has constantly availed himself of the knowledge he was acquiring of their recent representatives, the award of the Lyell Medal to him is consistent with the wishes of its great founder.

Mr. Hulke, in reply, said that, although he regretted that circumstances had prevented Mr. Busk from being present to receive personally the award of the Council, it was with great pleasure that he undertook to be the means of conveying to that gentleman this testimony of the Society's appreciation of his palæontological labours. Mr. Hulke also read the following letter, which had been received from Mr. Busk:—

"32, Harley Street, Feb. 11, 1878.—Dear Mr. President,—I much regret that I shall be unable to attend the Anniversary Meeting, and have therefore to beg that you will be kind enough to express to the Council my very grateful sense of the honour they purpose to do me in the award of the Lyell Medal. There is none I could esteem more highly, coming as it does from a body with which I have been so long connected and containing so many old and valued friends, whose opinion, as thus expressed, of the little I have been able to do in the cause of Geological Science, has afforded me the greatest gratification. The testimonial is doubly pleasing also from its being associated with the name of one whom, when alive, we all so much esteemed and loved, and whose memory will be venerated in all future time. With my best thanks to yourself and the Council, believe me, dear Mr. President, yours sincerely, Geo. Busk.—To the President of the Geological Society."

In handing the balance of the proceeds of the Lyell Fund to Dr. Oldham, F.R.S., F.G.S., for transmission to Dr. Waagen, the President said:—Dr. Oldham,—In asking you to forward Dr. W. Waagen, of Vienna, and who was lately on the Geological Survey of the East Indies, the Balance of the proceeds of the Lyell Fund, I perform a very pleasing duty. Dr. Waagen's labours in India have commended themselves to the Council on account of their great merit and interest, and we sincerely regret that he has suffered from the climate and from overwork. His palæontological work has been admirable, and his great knowledge of the Ammonitidæ has enabled him to arrange and identify the geological series of Cutch. His classification and his careful analysis of species has placed him in a high rank amongst his fellow-labourers in science; and I trust that you will be able to satisfy him that his English brethren sympathize most thoroughly with him.

Dr. Oldham, in reply, said:—It is, Sir, to me a source of true gratification to have been able to comply with Dr. Waagen's request, and to receive on his behalf the award which you have just announced; and this because, in all probability, it has fallen to me to be more intimately acquainted with Dr. Waagen than any one here present, inasmuch as for some years I had the happy good fortune of his co-operation on the Geological Survey of India, as an assistant, a colleague, and a friend. And it will always, as it is now, be to me a pleasure to be able to bear testimony to the untiring devotion, zeal, and ability which he brought to his work, and to the regret which we all felt when continued ill-health compelled him to resign his connexion with India. I greatly regret to say that ill-health has continued, and has, in his native country, prevented his obtaining such employment as would bring with it even the poor remuneration which science commands. The award of the Geological Society of London will therefore prove to him a great solace in his depression, and a great stimulus to his further exertion. With your permission I will read to you a few words from Dr. Waagen's letter to myself. He says he had received with mingled feelings of pride and gratitude the announcement of the award. "I do not know how I have deserved the high honour the Geological Society of London has in mind to confer upon me. I know only that I have always endeavoured to do my duty as long as my strength lasted, and I hope to do my duty to science again as my strength returns. It will be a great inducement to me to use now so much the more my utmost zeal and endeavours to show myself worthy of the high distinction I am to receive at the hands of the Geological Society. I wish I were able to attend personally to express before the assembly of the Council and Members of the Geological Society the feelings of gratitude which have been awakened through the great kindness shown to me. A journey to London, however, at this time of the year, would be death to me. I cannot do anything, therefore, but ask you to express, if possible, my warmest thanks to the Society for the great honour they have deemed me worthy to receive."

The President then proceeded to read his Anniversary Address, in which he dwelt in considerable detail upon the influence of advanced morphological and zoological investigations upon our palæontological ideas and upon the geological inferences founded upon them. The Address was prefaced by some obituary notices of Fellows of the Society deceased during the past year, including Sir Henry James, Dr. Bryce, Mr. John Leckenby, Dr. Bowerbank, Mr. E. Wood, and Mr. W. Harris.

The ballot for the Council and Officers was taken, and the following were duly elected for the ensuing year:—*President:* H. C. Sorby, Esq., F.R.S. *Vice-Presi-*

*dents:* R. Etheridge, Esq., F.R.S.; John Evans, Esq., D.C.L., F.R.S.; Prof. J. Prestwich, M.A., F.R.S.; Prof. A. C. Ramsay, LL.D., F.R.S. *Secretaries:* Prof. T. G. Bonney, M.A.; Prof. J. W. Judd, F.R.S. *Foreign Secretary:* Warington W. Smyth, Esq., M.A., F.R.S. *Treasurer:* J. Gwyn Jeffreys, LL.D., F.R.S. *Council:* H. Bauerman, Esq.; Prof. T. G. Bonney, M.A.; Prof. W. Boyd Dawkins, M.A., F.R.S.; Prof. P. Martin Duncan, M.B., F.R.S.; R. Etheridge, Esq., F.R.S.; John Evans, Esq., D.C.L., F.R.S.; Henry Hicks, Esq.; W. H. Hudleston, Esq., M.A.; Prof. T. McKenny Hughes, M.A.; J. W. Hulke, Esq., F.R.S.; J. Gwyn Jeffreys, LL.D., F.R.S.; Prof. T. Rupert Jones, F.R.S.; Prof. J. W. Judd, F.R.S.; J. Morris, Esq.; J. A. Phillips, Esq.; Prof. J. Prestwich, M.A., F.R.S.; F. G. H. Price, Esq.; Prof. A. C. Ramsay, LL.D., F.R.S.; R. H. Scott, Esq., M.A., F.R.S.; Warington W. Smyth, Esq., M.A., F.R.S.; H. C. Sorby, Esq., F.R.S.; Admiral T. A. B. Spratt, C.B., F.R.S.; Rev. T. Wiltshire, M.A., F.L.S.

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III.—February 20th, 1878.—Henry Clifton Sorby, Esq., F.R.S., President, in the Chair.—The following communications were read:

1. "Notes on the Physical Geology of the Upper Punjàb." By A. B. Wynne, Esq., F.G.S.

The author stated that crystalline rocks are rare in the accession parts of the Upper Punjàb district, and that when present they consist of syenite and gneiss. The Cambrian and Silurian formations are represented by more or less metamorphosed azoic slates in the Himalayan district, and in the Salt Range by a zone less than 200 feet thick, containing either *Obolus* or *Siphonotreta*, underlain by a thick unfossiliferous sandstone, beneath which is a deposit of gypseous marl and salt. Above the Silurian in the Salt Range, and conformable to it, comes the Magnesian Sandstone group and a group of unfossiliferous sandstones and clays; in the Himalaya these deposits are probably represented by an unfossiliferous siliceous dolomite, which rests unconformably upon the slates. There are no fossils indicative of rocks of Devonian age. The Carboniferous rocks, which are also conformably deposited on limestones, sandstones, and shales, the last sometimes carbonaceous. These deposits contain hæmatite in pockets, and the oldest known Ammonites have been found in them. An infra-Triassic group occurring in Lei Bau mountain consists of red shales, sandstones, and red quartzitic dolomites, overlain by lighter-coloured siliceous dolomites, which in their turn are covered by hæmatite, quartz breccia, sandstones, and shales. The author believes these to have been deposited by the same waters which subsequently laid down the Trias, which is largely composed of limestones in the northern Himalayan area, and here and elsewhere includes dolomites, shales, and sandstones. Numerous fossils occur in some of the beds, such as *Dicerocardium*, *Megalodon*, and *Nerinæa*. In the western part of the Salt Range conglomerates composed of great blocks are regarded by the author as evidence of proximity of land. The Jurassic deposits are local in their distribution, and consist of shales, sandstones, and limestones, containing abundant fossils, such as Belemnites, Ammonites, and Saurians. A dark limestone contains also *Gryphææ* and *Trigoniæ*. The Cretaceous deposits, when present, are conformable to the Carboniferous; they are variable in thickness and fossil contents, and are not recognizable near Attock between the Jurassic and Nummulitic groups. Further east a group, supposed to be Cretaceous, includes clays with boulders of crystalline rock, which the author regards as derived from land to the south. One of these boulders presented glacial striæ. The Eocene rocks are generally limestones, and lie conformably upon the subjacent formations. The Nummulitic series of the Salt Range includes gypseous and coaly shales. The salt beds sometimes attain a thickness of over 1000 feet. The Miocene and Pliocene deposits are of immense thickness, and contain only fossils of terrestrial and freshwater origin, so that the deposits were formed in lakes and inland seas. The Tertiary epoch closed with the elevation of the Himalayas and Salt Range, which was followed by a long period of change, during which various deposits were produced, some including great quantities of erratics, which, however, the author believes were brought to their present position rather by floating ice than by the extension of glaciers.

2. "Description and Correlation of the Bournemouth Beds. Part I. Upper or Marine Series." By J. Starkie Gardner, Esq., F.G.S.

The author stated that nothing had been written on this subject since Prof. Prestwich's paper, in which the beds at Hengistbury were described as of the Barton series. No attempt had hitherto been made to correlate the beds at Alum Bay or Whitecliff Bay with those of the mainland, and no reference was to be found anywhere to the origin and sequence of the beds between Hengistbury Head and Bournemouth, or to their contained fossils. He had now correlated these bed for bed with the strata at Alum Bay, and found that there is a sequence, and that the Hengistbury beds are higher than those of Bournemouth and do not reappear on the coast. They are all of marine origin and were deposited by a sea advancing from the south, as is shown by the slope of the shingle beds and the lenticular patches of clay which mark old channels parallel to the former shore and at right angles to the present cliff-line. They contain numerous fossils, fruits, leaves, Mollusca, and Crustacea, the fruits resembling those of Sheppey and forming a group of similar character. The Mollusca are of Bracklesham type, and the fossils include three genera of Bryozoa, two of which are new to the Eocene. The Crustacea have not yet been examined.

The author comes to the conclusion that the whole group is contemporaneous with the Bracklesham beds, and is not of Lower Bagshot age. Similar shore-conditions probably extended into the London basin, and the beds mapped by the Survey as Lower Bagshot are probably of the same age as those at Boscombe, in which case nothing more than the Bracklesham is to be met with in the London basin. The similarity of the leaves, etc., from Bovey Tracy to those obtained by the author leads him to infer that the former also are of Eocene, and not of Miocene age. The author increases the thickness of the London Clay at Alum Bay at the expense of the Bagshot beds, and diminishes that of the Bracklesham beds at Whitecliff Bay by transferring part of them to the Lower Bagshot.

3. "Notes on Certain Modes of Occurrence of Gold in Australia." By Richard Daintree, Esq., F.G.S.

The author stated that he had in a previous paper (Q. J. G. S. vol. xxviii. p. 271) proved the occurrence of gold in the Devonian rocks of Queensland, and further that the auriferous tracts were certainly confined to those districts in which the Devonian rocks were penetrated by certain plutonic rocks, principally pyritous diorites. These conclusions had since been confirmed by Mr. W. C. Wilkinson and Dr. G. F. H. Ulrich; and the facts thus established are of the greatest practical importance to miners. With regard to the epoch when the auriferous pyrites was deposited in the rocks, the author expresses the opinion that most of the pyrites is contemporaneous with the consolidation of the rocks in which it occurs, although some may have been subsequently introduced by infiltration; but this is not common in Australia. A more common case is the separation of gold generally diffused through a rock into local fissures, forming strings and veins. The author thinks that all the evidence goes to show that the Australian auriferous veins were chiefly formed during the earliest era of great volcanic agitation indicated by the condition of the stratified rocks, namely the Devonian, but that they were enriched during a subsequent Tertiary (probably Miocene) period of intense activity. No traces of auriferous veins have yet been found in any Mesozoic or Cainozoic deposits in Australia.

4. "Notes on the Geology of the Island of Mauritius and the adjacent Islets." By W. H. T. Power, Esq., B.A. (Communicated by W. Whitaker, Esq., B.A., F.G.S.)

The author stated that the island of Mauritius consists of an elevated central plateau, bounded by an incomplete wall of volcanic rock, round part of which there is a coral reef and coral sand-rock, and also rocks of various colours produced by the decomposition of volcanic rocks. Outside is a living coral reef. In the middle of the island the old crater-wall can be distinguished, although broken; two secondary craters are also noticed. On the north slope of the island there is a flow of columnar basalt to the sea. There is an opening in the old coral-reef, as in the existing one opposite the mouth of the Black River. Gabriel Island consists of a coral reef and detrital coral rock upon a foundation of basalt, the section showing in descending order:—1. Coral stone; 2. Conglomerate of coral, with some basalt pebbles and shells; 3. Compact limestone, with thin layers of basalt at base. The author described the supposed fossil trees noticed in this island by Messrs. Ayres and Clarke (Q. J. G. S. xxiii. p. 185) as composed simply of hard portions of coral rock left outstanding by the weathering of the softer intervening parts; they show the same stratification as the rock below. The islet known as Gunner's Quoin consists of columnar basaltic lava, capping volcanic sand, below which is a browner volcanic sand with seams of coral fragments. Flat Island is in part the remains of a volcanic crater, and the rest consists of volcanic sand strewn with coral blocks. There are basaltic dykes in the hill, the top of which appears to show traces of one or more plugs. The author concludes that Mauritius was once an active volcano, now elevated with the old reef. The islets also formed part of a volcano or volcanos, and have also been elevated with reef-material.

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IV.—March 6th, 1878.—Henry Clifton Sorby, Esq., F.R.S., President, in the Chair.—The following communications were read:

1. "On the Geology of Gibraltar." By Prof. A. C. Ramsay, LL.D., F.R.S., and James Geikie, Esq., LL.D., F.R.S.

In this paper the authors, after giving some account of the physical features of Gibraltar, described in detail the various rock-masses of which the peninsula is composed. The chief rock is a pale grey, bedded limestone, overlain by shales containing beds and bands of grit, mudstone, and limestone. Fossils are very rarely met with in the limestone, and have never as yet been found in the shales. The only recognizable fossil they obtained from the limestone was a *Rhynchonella*, which Messrs. Etheridge and Davidson think is most likely *Rh. concinna*. This would make the beds of Jurassic age. The limestone forms the great eastern escarpment, and dips west under the shales, which form the lower slopes upon which the town is built. The dips vary from 12° or 20° up to vertical. The connexion of these strata with the rocks of the adjoining districts in Spain and the opposite coast of Africa was traced, and it was shown that the Gibraltar Limestone reappears in Ape's Hill in Barbary, while the overlying shales and the sandstones of Queen of Spain's Chair form all the ground to the west of Ape's Hill up to Cape Spartel. The Jurassic strata of Gibraltar are overlain by various superficial accumulations, the oldest of which is a great mass of limestone-agglomerate, which is unfossiliferous, and shows as a rule no trace of stratification. It is made up of angular blocks of limestone of all shapes and sizes, and rests upon an uneven surface of limestone; it also covers wide areas underneath which only shales are present. It is excessively denuded, being worn into ravines and gullies, and presents generally a highly honeycombed surface. Terraces of marine erosion have also been excavated in it. It is not now accreting, and could not have been formed under present conditions of climate and surface. The authors gave at length their reasons for believing it to have been the result of a severe climate. The blocks were wedged out by the action of frost, and the heaps of angular *débris* thus formed were saturated by water derived from melting snows, and so were caused to flow *en masse* down the mountain-slopes and over the gently-inclined ground at their base.

The caves and fissures of Gibraltar were then described. It was shown that the true bone-breccias were confined to these. Many of these fossiliferous breccias are of later date than the great agglomerate, since they are met with in fissures and caves that intersect the limestone and limestone agglomerate alike. When the mammalia tenanted Gibraltar, Africa and Europe were united, and the climate was genial.

All round the rock occur platforms, ledges, and plateaux, which are evidently the work of the sea. These erosion-terraces are covered in many places with calcareous sandstones containing recent species of Mediterranean shells. Such marine deposits occur up to a height of 700 feet. The movement of depression was interrupted by pauses of longer or shorter duration, and the climatic conditions were probably much the same as at present.

After the rock had been re-elevated, the subaerial forces modified the surface of the marine sands that covered the limestone platforms, so that they came to form long sand slopes. The land at this period was of greater extent than it is now, and some grounds exist for believing Europe to have been again united to Africa, for mammalian remains occur here and there in the deposits that overlie the limestone-platforms. These relics, however, it is just possible, may be derivative. The climate was probably still genial like the present.

Overlying the marine and subaerial deposits just referred to occurs an upper and younger accumulation of massive unfossiliferous limestone agglomerate. This deposit the authors believe to owe its origin to severe climatic conditions. After the marine deposits that cloak so much of the eastern side of the rock had been weathered into subaerial sand-slopes, large blocks were detached from the cliffs and steep slopes, and these dropped down upon the sand and were soon drifted over. By and bye the blocks fell in such quantities that the sand-slopes in many places were completely buried under a talus of limestone *débris*. This was subsequently consolidated by infiltration into a solid agglomerate, in the same way as the underlying sands were hardened into sandstone. These sandstones contain a few blocks of limestone only in their upper portions. In their horizontally bedded and lower-lying portions no limestone blocks occur.

This later agglomerate bears every stamp of great antiquity, and could not have been formed under present geographical and climatic conditions. The surface is honeycombed and worn, just like that of the solid limestone and the older limestone agglomerate. Since its accumulation the climate has greatly changed, the present being characterized by the absence of frost.

In concluding the authors discussed at length the cause of the cold conditions that gave rise to the great limestone agglomerates, and argued that this cause could not have been *elevation of the land.* They also pointed out that a *submergence of the Sahara* would be equally incompetent to bring about the desiderated climatic conditions, and that even a former much greater elevation of the land, combined with the appearance of a Sahara sea, would fail to supply us with the severe winter climate that was necessary to produce the great agglomerates. They thought that the most probable explanation of the phenomena described is that the cold conditions referred to were contemporaneous with that general refrigeration of climate which took place over so vast an area in our hemisphere during Pleistocene times. The limestone agglomerates they look upon as the equivalents of those glacial deposits that occur so plentifully in our own and other countries, and the bone-breccias, which are intermediate in date between the lower and upper limestone agglomerates, are paralleled by the interglacial beds of the British Islands, Sweden, Switzerland, etc.

2. "Notes on the Geology of Japan." By J. G. H. Godfrey, Esq., F.G.S.

The author stated that Yesso, the most northern island of the Japanese group, had been geologically surveyed under the direction of Mr. Lyman, but that the geology of the other islands was chiefly known from Richthofen's general description. He finds that the classification of formations proposed by Lyman for Yesso holds good in all the other islands. Thus, going from newer to older deposits, he distinguishes:—

1. New alluvium, formed by existing rivers.
2. Old alluvium, formed by ancient rivers.
3. New volcanic rocks, consisting of basalt and rhyolite. Most of the Japanese volcanos are extinct, but a few, such as Asamoyama, are in the solfatara stage; hot springs abound, and earthquakes are frequent.
4. Toshibetsu group, middle or lower Tertiary sandstones, clays, and conglomerates, containing lignite and petroleum.
5. Old volcanic series, rhyolitic rocks, often distinctly bedded, covering a vast area, and with numerous lodes and deposits containing gold, silver, copper, lead, and blende.
6. Horimui group, a coal- and lignite-bearing series of considerable extent, apparently best developed in the western part of Japan, and especially in the north of the island of Kiushiu, where the deposits are shown by fossil evidence to be of Cretaceous age.
7. Kamoikotan or metamorphic group, consisting of various schistose and gneissic rocks, distinctly stratified, and usually showing a dip of upwards of 60°. Owing to the absence of fossils the age of this group is still undecided; Richthofen regards it as Silurian or Devonian. Granite and diorite are frequently intruded into this series, and they contain some important mineral veins.

The author went into considerable details upon the useful minerals of Japan, noticing their mode of occurrence and the quantities in which they are produced. The most important of them are:—coal and lignite, copper, silver, gold, iron, petroleum, lead, and tin; those of less consequence are:—sulphur (from the old craters), antimony, mercury, kaolin, and salt.

## CORRESPONDENCE.

### WHAT IS AN ERRATIC?

Sir,—I am constrained to ask the above question in consequence of the appearance, in the Records of the Geological Survey of India (vol. x. p. 223), of some critical remarks by Mr. Theobald, upon my previous reference to the "Erratics" of the Upper Punjab in the same volume (p. 123).

In these remarks Mr. Theobald restricts and applies the term "*Erratics*" exclusively to certain blocks supposed to have been ice-transported, advocating the idea also (*vide* foot-note) that the word is only applicable in describing recent phases of geology.

Every field geologist must have observed travelled rock-fragments, the connexion of which with glaciation was not apparent, and to which the comprehensive term "*Erratic*" would be perfectly applicable. Such transported fragments might have come from some neighbouring mountain, or have been transported by a large river, or drifted by a marine current, or ice might have moved them. In all these cases I hold that the fragments would be truly *erratics*, no matter at what period of geological history they wandered; also that glacial erratics may be included in the general term.

Chalk flints are found in the shore deposits of the South of Ireland. They may have come from France, or the South of England, from Antrim, or from unknown Chalk beds beneath the English Channel, but there is no evidence that they have been transported by ice. The materials of the Chesil Bank are accumulated by marine currents. The agency which enclosed Wicklow granite masses far within the Carboniferous Limestone of the County Dublin; or the great blocks of granite in a flow of Deccan Trap near Mundlaisir, on the Nerbudda, in India, are unknown: but are not these as genuinely erratics as any ice-borne blocks? If not erratics, what else are these travelled fragments to be called?

The erratics of the Upper Punjab are of various kinds. One group of them dates very far back; these are all fragments of crystalline rocks, including many of red granite from an unknown source, and they occur imbedded in the geological series of the Salt Range, at every stage from pre-Silurian to latest Tertiary or Recent. Another group is of Himalayan origin; these have been transported from the north during Tertiary, post-Tertiary, and Recent periods, and are still travelling from the same direction: they include a great variety of Himalayan rocks. Yet another group comprises large angular and sub-angular blocks of Himalayan gneiss, granite, limestone. etc., which are supposed to have been carried by floating-ice. Nothing has yet been advanced to connect them with glaciation of the immediate localities in which they are found.

Some very large angular, red granite erratics, at considerable elevations on the Salt Range, and resting on different strata, are probably also attributable to flotation by means of ice. The best known of these is the Khewra Erratic.

Other smaller, rounded, erratic boulders of red granite, locally numerous on or near the eastern Salt Range, but not entirely absent to the west, are supposed by me to have been mainly released by denudation from a Boulder-clay of probably Cretaceous age, which only occurs in the eastern part of this range. Among these latter boulders one has been found (not *in situ*) bearing marks of glacial smoothing and striation.

With regard to both these rounded erratic boulders and the larger angular blocks, it is a question of interest, but of considerable difficulty, to decide by what means they were transported. The largest have no representatives as to size in the neighbouring Cretaceous (?) boulder bed, the fragments in which are usually rounded. Mr. Theobald suggests as their source a Palæozoic boulder zone of the range, and their derivation thence by weathering *in situ*; but this is impossible, for the Palæozoic boulder beds referred to never existed in the eastern Salt Range, or in the vicinity of these blocks! They may therefore have been transported, as well as the northern ones, by floating-ice.

The smaller rounded and glaciated boulder just now mentioned would suggest Cretaceous glacial conditions with some probability, had it been found *in situ*. As it occurred in a wall (though near the boulder bed), its scoring and smoothing may have taken place either before or after its removal from that bed, supposing that it ever was included therein—a point incapable of proof, but open to conjecture.

At whatever period this particular boulder became glaciated, the fact suggests that any of the similar boulders about the Salt Range may have been originally glacial erratics: also that glacial conditions may have prevailed during any period to which the deposition of these boulders can be traced, from Palæozoic to Recent.

Rather than admit a possibility of connexion between recent ice-work and the occurrence of these smaller granite erratics, Mr. Theobald prefers to assert their derivation, proximately from the Cretaceous Boulder-clay, but more immediately from weathering of the latest Tertiary conglomerates, because in a few instances he has found blocks of red granite in the last-named beds. This view I consider is untenable for two reasons, first on account of the number of the red granite recent erratics, next because the general parallelism pervading the whole of the eastern Salt Range series, from the oldest beds upwards, involves the Cretaceous Boulder-clay having been buried under many hundreds of feet of earlier Tertiary strata at the time when the few granite boulders of the uppermost Tertiary conglomerates were enclosed.[1]

From the whole of the facts regarding these red granite erratics, large and small, I think the fair inference is that red granitic rocky ground, lying probably to the south of the Salt Range, was being

[1] There is some indication of a break in this Tertiary series, for apparently rolled fragments of Nummulitic Limestone are found in it at various scattered horizons, but the beds are all parallel. And there is no evidence that any rock of the Salt Range older than Nummulitic was being eroded during Tertiary deposition. The Cretaceous (?) Olive group is, however, older than the Nummulitic, and ought to have been covered duriug deposition of any subsequent beds.

denuded and furnishing erratics, during the deposition of the whole Salt Range series; and further, that towards the later period (if not before) glacial conditions of the granitic region enabled masses of this rock to be floated to the Salt Range area by the agency of ice; there to undergo, in varying degrees, the usual operations of atmospheric denudation. A. B. WYNNE.

CAMP HAZARA, *January* 1, 1878.

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MR. S. V. WOOD, JUN., IN REPLY TO DR. JAMES GEIKIE.

SIR,—Mr. James Geikie has not in his article in your last Number put the questions in issue between us so incisively as I could have wished.

1. I have never denied that land-ice erodes more in some places than it does in others. What I say is that if the great basin of the St. Lawrence has been eroded by this agency, all land surfaces must have perished in the process.

2. I have never denied that some moraine accumulates beneath ice. What I say is that nearly all of it travels out to the ice termination. If it does not, how can valleys and basins be eroded by ice? If the bulk of what is degraded remains beneath the ice, no basin can result; for the moraine would to the same extent supply the place of the rocks degraded. It is only near the termination of the glacier that any considerable quantity of the moraine accumulates beneath the ice. This (as distinguished from the first accumulated portion of it, which resting on the middle glacial for the most part, though not always, was formed by the dropping of the moraine from floe-ice) I consider to have been the origin of that later part of the chalky clay which covers Lincolnshire, Huntingdonshire, Cambridgeshire, and the adjoining district, accumulated in this way when the glacier which I have described as coming southwards over Lincolnshire terminated in the sea some twenty or thirty miles west of the Fen boundary; as well as of that which forms the basement clay of Holderness, which accumulated from an arm of this glacier that came through the Humber. All this moraine, as I hope some day to show in detail, was, except in two or three limited spots, left beneath the sea as the ice wasted away. The part in Holderness being followed by the depression northwards which brought over the Shap blocks, was succeeded *un*interruptedly by another deposit of material from a different source, the purple clay; while the rest being in shallow water emerged before any such new deposit could form over it.

3. Mr. Geikie speaks thus of sands escaping the action of the overriding ice, viz.: "Where the gradually decreasing ice-sheet crawled slowly to its termination, we discover considerable accumulations of Till, resting upon apparently undisturbed beds of gravel, sand, and clay"; and again he says, "That an ice-sheet does under certain conditions ride over incoherent deposits of gravel, sand, silt, clay, and peat without entirely obliterating them."

Possibly the latter of these two statements may to some extent be true, but not the former. Let us test the case by that of the North Suffolk Cliff, which from Kessingland to Yarmouth, a distance of fifteen miles, forms the natural section of a tract of country of similar structure which extends inland for nearly forty miles; and over which tract, whenever pits show the junction of the sand with the clay, they disclose exactly the same features attending it as the cliff does. Now this cliff, except where the valley denudation interrupts it, is formed by a continuous deposit of undisturbed horizontally bedded sand, containing marine mollusca and other marine organisms, overlain nearly throughout by the morainic clay, often twenty, and averaging fully twelve feet in thickness, the junction of the two being absolutely undisturbed except in one or two places where, for a space of a very few yards only, the clay slightly dents into and disturbs the top of the sand, showing as it appears to me places where floes grounded; and the only departure from this in the district inland is that bosses of the contorted Drift occasionally protrude there through the sands. Now I say that it is a physical impossibility that the whole of this thick sheet of morainic clay, fifteen miles wide by forty long, can have been dragged for forty miles over the sand without either crumpling or destroying it in the least, and without incorporating part of such sand and of the contorted Drift bosses into itself. This impossibility becomes more striking if we supplement the weight of this sheet of clay by the many-fold greater weight of the ice which Mr. Geikie contends overlaid and dragged it, "gradually diminishing" though that ice may have been from the prodigious thickness usually appealed to by Mr. Geikie.

I hope that in the above I have made the distinction between our views clear; and I venture to think that Mr. Geikie, with his numerous interglacial periods, his exaggerated ice-sheets, and his assumption of the truth of Dr. Croll's theory, is hardly the person who should charge those who differ from him with "preconceived ideas" in glacial geology. S. V. Wood, jun.

February 16, 1878.

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## ON THE TRILOBITES OF THE SHINETON SHALES.

Sir,—Among the fossils described in Mr. Callaway's interesting paper on the Upper Cambrian Rocks in South Shropshire (Quart. Journ. Geol. Soc., vol. xxxiii. p. 652 *seqq.*), there are some Trilobites of whose relations to forms previously known I might venture a few suggestions.

I do not think that *Conocoryphe monile* is very nearly related to such species as *C. striata*. By the strongly-lobed glabella and the dotted marginal furrow, it approaches to Angelin's *Euloma*, a genus characteristic of the Swedish *Ceratopyge* Limestone, which occupies about the same position as the English Upper Tremadoc. The fauna of the *Ceratopyge* Limestone is decidedly Lower Silurian, but also the Tremadoc group—at least the Upper—has to me always seemed to be, palæontologically, more related to the Silurian than to the Cambrian. The Lower Graptolite Schists immediately overlying the

*Ceratopyge* Limestone are a distinct equivalent of the English Skiddaw.

*Conophrys* can hardly be separated from the *Shumardia* of Billings (Pal. Foss. Canada, vol. i. p. 92), which occupies a somewhat similar, perhaps a little higher horizon. To the same genus probably also belongs the *Battus pusillus* of Sars (Isis, 1835, p. 334, t. viii. fig. 2=*Agnostus* or *Olenus pusillus*, Kjerulf), which occurs near Christiania together with *Ceratopyge forficula.*

As to *Lichapyge,* it cannot have any affinity to *Paradoxides,* and hardly to *Lichas.* I little doubt that it is most nearly allied to *Remopleurides,* if not a true *Remopleurides.* In some species of *Remopleurides,* as *R. dorsospinifer,* Portl., it is very usual to find the pygidium united with the two hindmost thoracal segments. The fossil described as *Lichapyge* would have almost the same shape, if the terminal limb had two denticles on either side.

The subgenus *Platypeltis* seems to be more nearly related to *Niobe* than to the genuine *Asaphi.* Also *Niobe* is characterized by not having the hypostoma forked. G. Linnarsson.

Geol. Survey Office, Stockholm, *March 4th,* 1878.

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## GEOLOGICAL MAP OF SCOTLAND.

Sir,—Since the publication of my review of Prof. Geikie's Geological Map of Scotland, it has come to my knowledge that the vast mass of new detail inserted thereupon in the areas south of the Grampians, instead of being due to a digest of Survey work, is in truth the result of the author's recent personal investigations. The map has been the constant occupation of his leisure hours for many years, his summer holidays being generally given up to journeys for its extension and improvement. Even the remarkably minute mapping of the Old Red and Volcanic series of Fife and Forfar, the trappean belt of the Solway, etc., noted by us for especial commendation, was completed by himself before the Survey moved into those districts. Though this deprives the map of anything like an official character, it adds much to its general reliability. It is indeed highly satisfactory to feel assured that all the new work is by the same hand, and that consequently the details throughout are as trustworthy as those within the areas already covered by the Survey. Looked upon as the simple product of individual original research, the map is a monument of rare geologic skill and energy. The author is to be congratulated on having, single-handed, accomplished his task with a perfection and completeness that—however widely views may differ as to the expediency of his new systematic arrangements—has charmed all those whose opinion is worthy of a moment's consideration. Chas. Lapworth.

St. Andrews, *March 20th.*

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## DR. CARL MAYER ON THE ITALIAN TERTIARIES.

Sir,—In the last number of the "Bolletino del R. Comitato Geologico d'Italia" there are again several important papers on the Italian Tertiaries, but that of Dr. Carl Mayer calls for special attention. Some few years ago Dr. Mayer published a paper, "Ueber die Nummuliten-Gebilde Ober Italiens," in which he correlated the Lower Tertiaries—which have in this peninsula their most important extension in the north-east, as in the Vicentine, and the present may, to a certain extent, be looked upon as a continuation of that communication.

This is a translation of a note on a coloured map of the north-western parts of Italy, which was presented to the Geological Society of France in 1877, and refers to the Miocene and Pliocene formations which occur in Central Liguria.

According to Dr. Mayer these Miocene and Pliocene beds, from the Ligurian to the Astian, have here a thickness of 22,000 to 23,000 feet. When we consider how much more largely the last two étages of the Tertiaries are developed in the South of Italy, we do indeed see that the relative length of the Tertiaries has been but imperfectly appreciated. Nor, in considering the Cainozoic period, as a whole, should it be forgotten that the Lowest Tertiaries are less developed in Italy than in many places, and that, to get an idea of the time during which Eocene formations were being deposited, we must look to India.

Prof. Mayer is now willing to increase the calculation as to time of some of his étages, and thinks, for instance, he can now allow us as a minimum for the Messinian 40,000 years instead of 25,000. This may be satisfactory as far as we think it has any signification; but we must say that we have but little sympathy with these attempts to fix even a minimum for each stage, until we are in possession of more facts. Prof. Mayer, however, gives us his ideas of time for each of his divisions.

These papers show the importance of Mayer's attempts to introduce a uniform nomenclature for the divisions of the Tertiaries, and his terms, if generally introduced, would prevent us finding Italian deposits called "Schlier," "Leithakalk," "Sarmatische stufe," etc.

A. W. Waters.

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TERMINAL CURVATURE IN WEST SOMERSET, ETC.

Sir,—You would oblige by finding space for a few remarks on a very controversial paper by Mr. Ussher, which has just appeared in the Quart. Journ. Geol. Soc. About ten years ago I communicated a paper to the Geological Society on what I called the Terminal Curvature of Slaty Laminæ (principally on the flat summit of Brendon Hill, Somersetshire), and suggested a number of causes for the consideration of geologists, *none of which I confidently advocated.* So far as I can remember, all the geologists who afterwards expressed their opinion on this and other instances of terminal curvature agreed with me in preferring the idea that ice in some form had been the moving agent, with the exception of Mr. Darwin, who stated that he had attributed somewhat similar phenomena in S. America to earthquakes. I will not occupy your valuable space by controverting all the objections which Mr. Ussher has brought forward to my suggestions; but on reconsidering the subject, I cannot help believing that land-ice or floating-ice would have furnished a more uniformly-directed and horizontally-operating cause of the curving back of slaty laminæ over a large area on the flat summit of Brendon Hill than the agency principally advocated by Mr. Ussher, namely, "oft-repeated internal movements," producing curves, flexures, and contortions, and revealed at the surface by the planing action of denuding agents. The chances against the irregularly-degrading action of subaerial denuding agents having stopped short over a large area along the horizontal plane where the summit of the curved-back slaty laminæ occurs, must have been exceedingly small, while the presence of blocks of quartz imbedded in the more shattered parts of the curved-back laminæ (blocks which must have been carried, or pushed forward, on perfectly level ground, to considerable distances from their native veins) cannot be reconciled with the internal movement theory. Mr. Ussher regards the "Head" as a subaerial accumulation, but Sir R. I. Murchison long ago, and Mr. Belt and Prof. Prestwich lately, have proved that it must have been deposited under the sea or an immense ice-water lake. It may yet turn out to be equivalent to the Upper Boulder-clay of the North-west of England. Neither can I agree with Mr. Ussher in supposing that the south-western counties, any more than the north-western, underwent a "great surface-waste and contour-moulding in Pleistocene times." In the north-west no fact forces itself more on the attention than the Preglacial origin of all the leading varieties of surface-configuration, especially the valleys. This, I believe, is admitted by all geologists who have studied the subject.

D. Mackintosh.

P.S.—Since the above was written, I have noticed that Mr. Ussher regards the "intrusion of roots acting as wedges" as the "most common cause of strictly superficial curvature." In all the instances described in my paper in the Quart. Journ. Geol. Soc., for November, 1867 (excepting the one at Gupworthy), the curving back of the slaty laminæ is confined to a space only a few feet in depth. A very little reflection must show that the intrusive action of roots could never have *persevered in one direction in bending back the inclined laminæ against their nap.* With regard to the comparative absence of curved-back laminæ on the northern slope of Brendon Hill, if the direction and high angle of the cleavage dip be there the same as on the summit of the hill, Mr. Ussher is not right in implying that ice moving up to the northern slope would encounter more resistance from the nap of the laminæ than on the summit, as a simple diagram will show.

D. M.

## MISCELLANEOUS.

Society of Arts Blowpipe Prize.—The Council of the Society of Arts has awarded to two Cornishmen, Messrs. Letcher of St. Day and Camborne, the Silver Medal of the Society, and a Prize of £10, for the best set of Blowpipe Apparatus which could be sold retail for One Guinea.

## Note on 'Jadeite' and 'Jade.'[1] By Thomas Davies, F.G.S.

### Jadeite (Damour).

Specific gravity 3·28 to 3·4; hardness 6·5 to 7. Colours milky-white, with bright green veins and splotches, greenish-grey, bluish-grey, clear grey and translucent as chalcedony, orange-yellow, smoky-green passing to black, apple-green, sometimes emerald-green, all the green tints as a rule much brighter than in the Oriental jade, also, but rarely, of violet shades. Texture from compact, to crypto-crystalline, and distinctly crystalline, sometimes coarsely so; fibro-lamellar, opaque to translucent and sometimes transparent.

Thin splinters will fuse in the flame of a spirit lamp. Damour, from analyses made by him, suggests its affinities to the epidotes.

*Localities.*—Central Asia, and particularly China; also as articles worked by the Aztecs, Mexico.

### Oriental Jade (Damour).[2]

Specific gravity 2·96 to 3·06; hardness 5·5 to 6·5. Colours white and white variously tinted, greenish-grey, many shades of green. Texture mostly compact, rarely cryptocrystalline.

Found chiefly in Central Asia, particularly in China and on its borders. Also in New Zealand and the Pacific Islands generally.

Specific gravity of upwards of 100 specimens from New Zealand determined by myself have been within the limits of 3·00 to 3·02, by far the larger number giving 3·01.

### Oceanic Jade (Damour).

Specific gravity 3·18; hardness 5·5 to 6·5. Of this variety I possess no personal experience, the large number of objects of jade which have come under my observation not having yielded me one example. Damour, however, who examined four specimens, states that in its aspect and general characters—with the exception of its density—it much resembles the Oriental jade. It, however, possesses a somewhat silky lustre, due to exceedingly delicate fibres which traverse the mass. I have met with this structure frequently however in the jade from New Zealand, which possessed the density of 3·01. From an analysis Damour refers it to the pyroxene group, whereas the Oriental is referable to hornblende. Vars. Tremolite or Actinolite.

Found in New Caledonia and Marquise Island, Pacific.

None of these minerals to my knowledge have been met with *in sitû* in Europe, though the British Museum possesses a fragment of unworked Oriental jade purporting to have been found in Turkey.

[1] The above Note was communicated by my friend Mr. Davies to the translator of "Keller's Lake-Dwellings," and appears in the Appendix to the second edition of that work, just issued by Messrs. Longmans. Its object is to correct some inaccuracies regarding the use of the terms 'Nephrite,' 'Jade,' 'Jadeite,' etc. It appeared to be so interesting that, with the writer's permission, it is reprinted here.—Edit. Geol. Mag.

[2] Damour makes the old name 'Nephrite' a synonym both of Oriental and Oceanic Jade; the term Nephrite being generally abandoned by Mineralogists.—T.D.

C. L. Griesbach lith. W. West & Co. imp.

The Coast of South Devon, near Sharkham Point, looking West.
(From a Photograph by Brinley, Totnes.)

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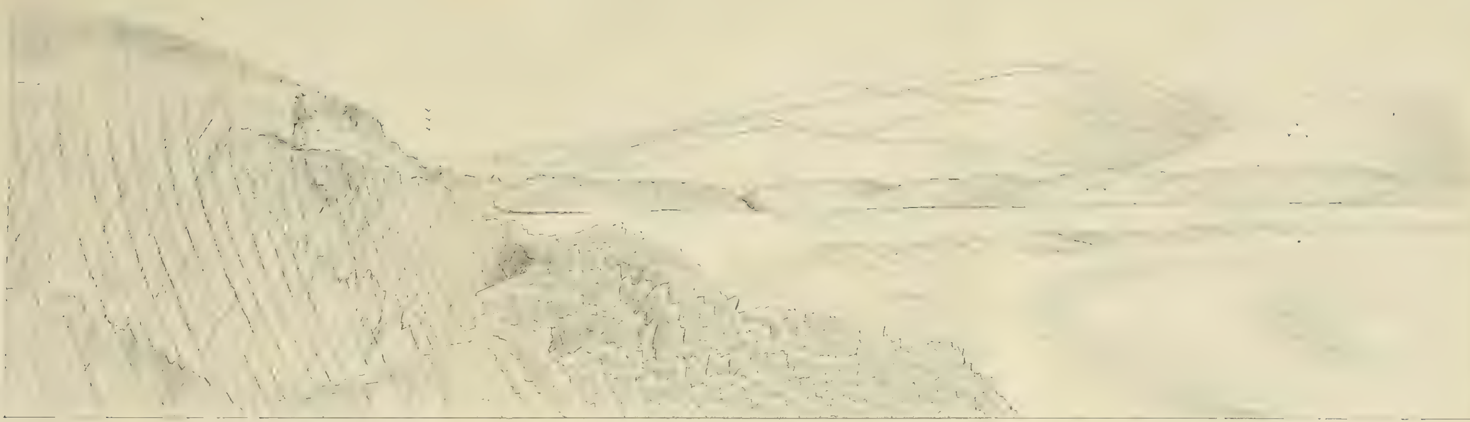

Fig 3. Sketch at Woolacombe, North Devon

Morte Slates · Woolacombe · Sand-hills (Æolian) · Potters Hill, and part of Pickwell Down (right)

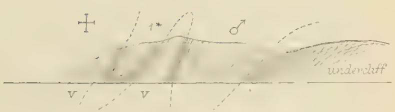



Fig. 1

To illustrate Mr Champernowne's paper on the Devonians of N & S. Devon.

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No. V.—MAY, 1878.

## ORIGINAL ARTICLES.

### I.—Notes on the Devonians and Old Red Sandstone of North and South Devon.

By A. Champernowne, M.A., F.G.S.

(PLATES V. and VI.)

It may seem to many geologists, accustomed to speak of the "simple order of North Devon," a somewhat unusual process to fall back on the more troubled districts of the southern division of the County for evidence upon which to take one's stand in interpreting the grand facts of succession within the original "Devonian" area, Devonshire. That is, however, the plan of campaign which I shall adopt; but instead of publishing the paper I read last year before the British Association, in Section C, at Plymouth (which will appear in abstract in the Annual volume of Reports), I will only recapitulate the facts I then brought forward, relating to the southern limestones of Torbay.

In doing so, my chief reason is that I have heard the value of that evidence denied, and the original reading of the section strictly adhered to.

In the two diagrams on Plate VI. Figs. 1 and 2, (1) represents the limestone of Berry Head, and the flap of the same south of Mudstone Bay; (2) the slates of Mudstone Bay; (2*) the slaty rocks of a slightly different aspect south of the limestones; (3) red sandstones corresponding to those of Staddon Heights and Mount Edgecumbe; (4) intrusive trap altering the rocks at the contact; (♂) hæmatite iron-ore deposited in the hollows of the limestone, and not a bed, as sometimes represented.

It will be observed that (1*) is a trough of the limestone beds, the bottom of which is clearly seen; close beyond it unites with the main mass. The right-hand tongue of trap forms the extreme headland of Sharkham Point, the limestone adjoining it on the right being nearly vertical, whereas it sets on at the southern end of Mudstone Beach at an angle not greater than 45°.

Now I contend that in the minor trough *which we can see,* we are furnished with a direct clue to the structure of the main mass, the bottom of which is not seen, but is at some depth below the sea. I believe that such dotted lines as those in diagram (1) are natural, but that those of diagram (2) are scarcely conceivable. The minor trough cannot be ignored, and I cannot imagine it possible that a portion of the slates (2*) can have been introduced between the two parts of limestone if they (the slates) are really newer beds. Therefore I conclude that they are not newer beds, but that all the rocks on the left of the diagram are older than the limestones. This brings the Red Sandstones (3) into direct and natural relation with those of Cockington, the Warberry, Lincombe, etc., at Torquay, *which are beneath* the limestones.

I may add that thick-bedded red sandstones on the strike of (3) in the Halwell Valley, nine miles to the westwards, dip north, the Harbertonford limestone also dipping north, though thrown by a N. and S. fault on its east; and I believe that as soon as the boundaries shall have been accurately surveyed, the real infraposition of the red sandstones will be established beyond doubt.

Now, having at Plymouth received from my opponents, of whom not the least formidable was my friend Mr. Pengelly, our Sectional President, a sort of challenge to study North Devon, about a month later I took the hint, especially as I had not visited that part of the country since the time when I held opinions widely differing from those I now believe to be true.

I first went to the north side of Morte Bay to see the Morte slates close to their junction with the Pickwell Down sandstones, and I give my notes almost as I took them.

Between Barricane Beach and Woolacombe the Morte slates dip at 65° and 70° S., crossed by cleavage dipping north at about the same angle; the latter dip was obviously not due to "surface bending," though that is sometimes seen in the neighbourhood. The reefs are a mass of jagged edges formed by the two sets of planes. Some very even quartz veins stand in the plane of the cleavage, and also vertical.

The slate is here distinctly bedded. Some beds are coarse and brownish, semi-arenaceous. One bed of brown sandstone 3 ft. 6 in. thick, obliquely traversed by quartz veins, is just like the Ilfracombe, etc., grits. With these exceptions, the character which the Morte slates bear of "fine-grained, smooth, glossy slates," will apply to them very close to the junction.

Still nearer Woolacombe the beds bend over as they rise, evidently forming part of a great denuded curve, as shown in the accompanying sketch, Plate VI. Fig. 3. The spot is about 200 paces from the foot of the blown sands, as near as I could take it for the advancing tide. Still nearer the sand hills the beds dip 80° S.

This curve, if not large enough *singly*, forms probably one of a series of curves which would carry the beds right over Pickwell Down, bringing them in again on the south.

Where the brook cuts through the sand hills at the Life-Boat House are some very smooth slates belonging to the Morte series. About 600 paces south of the Boat House is a reef of grey and purplish sandstones and slates dipping S. 65°. These should probably be included in the Old Red Sandstone; the boundary-line at any rate must be drawn somewhere about the foot of Potter's Hill.

The tide being almost full, I was unable to see much of the reefs which, according to Mr. Etheridge, are very well shown; but as long as there is the slightest misgiving as to the Pickwell Down beds being intercalated between the rocks north and south of them, they cannot, of course, help us in estimating the total thickness exposed.

In a country which has been so enormously subjected to denudation, the existence of such gigantic curves must be extremely difficult of proof, however strong may be one's suspicions, amounting to moral certainty.

We often hear of the simplicity of North Devon. I confess I cannot see it. Faults may be rare, and igneous rocks rarer still. But the instances of contortions with inversion, on a small and medium scale, are almost innumerable, and lead one to suspect the existence of far grander ones. Any evidence of such is not to be put aside without due examination.

Now, Mr. Etheridge states that the Morte slates cannot possibly be the same as the Pilton, etc., slates thrown off south of the Old Red ridge that runs into Somersetshire. He considers there is on the north a total absence of the brown sandstones containing *Cucullæa* and other fossils, which form a debatable ground between the Old Red and the true Carboniferous slates of Pilton, etc.

But even if we admit this, it is nothing more than what happens in many other districts. In the slate country, for example, west of the Dartington and Ogwell limestones, there is not a trace worth mentioning of the brown and grey grits and gritty slates (with *Pleurodictyum, Chonetes,* etc.), which, in Meadfoot Bay, underlie in force the Torquay limestone.

The Baggy brown sandstones, the Meadfoot and Looe *Pleurodictyum* beds, the Coomhola grits, and the brown grits from Combe Martin Bay to Ilfracombe, with many others (including the Spiriferen-Sandstein), fall, as I believe, into one and the same general horizon. In most of these "*Pleurodictyum*" itself occurs.

The peculiarly glossy character of the Morte slates may, I think, be accounted for by the very perfect cleavage, which is repeatedly cutting the undulated beds at right angles. Throughout the greater part of the Morte slates it is, as Mr. Etheridge says, most difficult to distinguish the bedding from the cleavage: still, making every allowance for peculiarities, I felt fully convinced that all the rocks from Combe Martin to Woolacombe constitute but one system, and that any division of them into Ilfracombe beds and Morte slates must be purely artificial.

It may not be so easy at first sight to account for the absence of calcareous matter near the southern side of the slate country which intervenes between the two tracts of red sandstones. There are, however, many considerations which may help to explain it, besides the possibility of thinning out. From Combe Martin westwards the series is excessively contorted, repeating the same beds again and again, with the same general dip. At Broadsand, on the west side of Combe Martin Bay, an inclined limestone V, inclosed in an offstanding rock,[1] comes into the country again at the Turnpike road

[1] A photograph in Frith's Series, No. 5901, shows this admirably. In fact much of the details might be noted down on the Six-inch Maps, from the great number of excellent photographs which illustrate this coast.

high above, only to be again doubled out; neither do I think it makes good its descent to any depth, but is ultimately underlain to the south.[1]

I next studied the section on the east side of Combe Martin Bay, and saw the *Stringocephalus* grits *in sitû.* I was struck by the identity of the red and variegated sandstones of the Hangman with those of the Smuggler's Cove near Torquay, where Mr. E. B. Tawney found *Myalina* (and *Natica?*) "in beds resembling the Hangman sandstones."

The Coomhola grit series succeeding is also in every respect identical with the *Pleurodictyum* beds at Meadfoot. The blackish slates, with cleavage crossing contorted brownish seams, the gritty slates and thin grits, the massive brown grits and the fucoidal (?) remains, are all one and the same from both bays. The boundary-line in West Challacombe Bay is well defined. At Torquay it corresponds with a combe on the eastern side of the Lincombe Hill. About the identity of these two horizons there can hardly be a doubt.

But, and I hope Mr. Etheridge will forgive me for being so troublesome, I think the Woolacombe horizon is also the same *inverted*, and that the Morte slates are the same as those we have been considering, but deposited under deeper-sea conditions, as indicated by the finer sediment.

The gritty series at Ilfracombe, where I was staying, is far less than its apparent thickness, owing to the great crumpling of the rocks, and corresponding portions on either side of a violently contorted trough must have been actually brought closer together in horizontal distance than they were before any disturbance had taken place, so that the change is less sudden than it appears.[2]

Then again, with the country south of Tavistock,—for miles around Buckland Monachorum, and Horrabridge, there is not a vestige of a real grit band in the Devonian slates, which, in every respect, are the same as the Morte slates, but most geologists, I apprehend, would agree that they (the slates of Horrabridge, etc.) are not newer than the Plymouth limestone on the one hand, or the Petherwin beds on the other.

*Supposing* the Pickwell Down sandstones to be really above the Morte slates, they, together with the fossiliferous series overlying them, must be *wholly unrepresented* in South Devon, because (*ex hyp.*) they cannot be any of the red beds of South Devon mentioned at the outset, all of which can be proved older than the slates and limestones. Every recorded instance of even apparent conformity between the Culm Measures and Devonians, whether slate or limestone, brings this conclusion nearer the verge of impossibility, the argument becoming cumulative.[3]

[1] I do not venture to say that there is *but one* limestone horizon, but there are certainly not so many as there are bands on the map.

[2] This is not a more striking change than that the Wenlock formation should in one tract consist of the Denbighshire grits, inseparable from its lower portions, in another of the Llantysilio flagstones, and thirdly of the soft calcareous shales and limestones of Siluria.

[3] I shall not now dwell upon this aspect of the subject, viz. the relations of the Culm Measures and Devonians. Mr. H. B. Woodward and Mr. Reid (of H. M. Geo-

I would also reason thus:—If we carry a formation, some thousands of feet thick, at a high angle, to an unknown depth, we are bound to show that it comes up again somewhere in some form or other, unless where a whole kingdom is masked by transgressive rocks, it may be Mesozoic or newer rocks. So, conversely, if the Staddon sandstones, with southerly dip, have swept over the Plymouth limestone and come down from the sky, *where did they go up?* The Pickwell Down sandstones *go down* south, under the Culm trough, so that will not do.

But if the Staddon beds are simply rucked up, and the curve cut away, then, in all probability, they would themselves be the equivalents of the Pickwell Down beds; and similar reasoning would apply to the latter in reference to the Haugman beds further north.

It makes no difference to the argument whether the group is everywhere continuous over the mineral axis of the two counties. But that sandstones and quartzites, whether red or no, do underlie the killas in some districts south of the Culm Measures, the St. Breock's anticlinal west of Bodmin clearly shows.

As far as I have gone hitherto, the evidence is, to my mind, all in favour of Jukes's views, if only for "great fault" we substitute "inverted anticlinal," *his alternative hypothesis:* showing, in short, that while the amount of disturbance is well-nigh incredible, the original order was comparatively simple.

Again and again, formerly, have I returned home perplexed, utterly unable to decide whether I had been working in upper or lower slates, so contradictory was the evidence. One quarry, that of Englebourne, where occurred in fair preservation fossils[1] like those of Wissenbach, Bundenbach, etc., deep below the Eifel limestone, came within a tract shaded on Dr. Holl's map "Upper South Devon"!

But since I have come to regard the Devonian slates *in their entirety* as one system, though most complex, with grits prevailing in the lower part, and limestone bands in the upper; now filling the whole space from Old Red to Coal Measures, the limestones only nodular or absent, and anon, as these bands come in and unite into masses of a thousand feet and upwards, dwindling away into mere passage-beds:—since then, I say, it is marvellous how one point after another, which before had been all obscurity, has flashed into the broad light of day.

It is useless to think of carrying on a field survey by means of continual appeals to the fossils: on the other hand there are, of course, innumerable instances where beds may be thus absolutely identified, especially where a formation (such as the Lias for instance) maintains its homogeneous characters over wide areas. This, however, the formations which intervene between the Upper

logical Survey) have laboured successfully in this field. I hope on some future occasion myself to describe a new area of Culm shales and grits resting in perfect conformity on Devonian limestones.

[1] A selection of these are, at this moment, in the Editor's hands for determination as far as possible.

Silurian and the Coal Measures are, as a whole, singularly remarkable for not doing.

An invaluable heritage left us by William Smith is the idea of "strata identified by organic remains"; but yet there remain the questions of currents, habitat and sea depth, life provinces, and so forth: and it may be that the "Devonian" or "Eifelian" life province of the Lower Carboniferous epoch is one of the most remarkable and well-defined life provinces of the past. But here we touch a whole circle of thought, to enter which would be beyond the scope of the present sketch.

The work must still be one of time, and I agree with the substance of Prof. Warington Smyth's remarks at Plymouth, that but little exhaustive work can be done before the Six-inch Maps are in the hands of the Geological Surveyors.

Should they show the Jukesites to be wrong, and succeed in proving that the *Stringocephalus*, as compared with the *Productus*, limestone, is something not "sui generis" merely, but *sui ævi* also, no one will less regret it, save for his admiration for the master mind of Jukes, than the writer of this paper.

*Additional Note.*—In speaking of the *Stringocephalus* Limestone as of Lower Carboniferous age, it is fair that I should guard myself from possible misapprehension.

Where two limestones run parallel for some distance, separated from each other by mechanical rocks, and characterized each by its own fossils, clearly we cannot give the same name to both, although we may include both in the same great system.

To explain more clearly. Suppose we are tracing a band of *Posidonomya* limestone among Culm Shales from west to east of North Devon, we find that, about Westleigh and Holcomb Rogus, changing its character, it approaches that of the Carboniferous Limestone of the Mendips. Still, as Mr. Horace Woodward has observed, it may represent only a part of that formation. Also, we know from Murchison's and Sedgwick's writings that if we follow the *Posidonomya* beds along the Westphalian frontier towards the Rhine, at Cromford near Ratingen they put on the characters of true Carboniferous Limestone with well-known *Producti.* This upper group is accompanied at some depth below by another limestone, the great Westphalian limestone, the Eifler kalk.

The strata by which the two limestones are separated are those known as Flinz (lowest), Kramenzel-stein, and (Spirifer-) Verneuili Schiefer, the whole classed as "Upper Devonian." Murchison (Siluria, 4th ed., p. 397) stated that, where most expanded, the group has a thickness of 1300 feet (1000 for the "Flinz" at Nuttlar).

Now, what parallel is there between this 1300 feet *maximum*, with no Old Red Sandstone, and the vast pile of sedimentary rocks represented by the distance from Ilfracombe to the Culm limestone at Fremington more than 9 miles as the crow flies? A pile, of which a part only, "the Pickwell Down sandstones," have been estimated at 3000 feet, and parts of the series north and south of them at higher figures still!

The probable truth is, I submit, that the whereabouts of the Ilfracombe limestone (= Eifler kalk) comes in again south of the Pickwell Down sandstones, among the Pilton slates; but the Coral polypes not having lived there, probably from deficiency of carbonate of lime, and excess of muddy sediment, the Coral limestone is absent, and naturally the Fauna is in the main distinct from that of the Ilfracombe area, the only limestone of any consequence being the Culm or *Posidonomya* limestone with which we set out.

Hence, by quite a different road, we arrive at the same conclusion as before, that is to say, that the Old Red Sandstone of Pickwell Down, etc., has been invertedly doubled up from beneath all the rocks to which the term "Devonian" can be assigned.

### EXPLANATION OF PLATES V. AND VI.

PLATE V.—The coast near Sharkham Point, looking west. [From a photograph by Brinley, Totnes.] Foreground shows crushed and folded limestone, the lowest beds of the great mass of Berryhead and Brixham (1* in Pl. VI.) Under these are reddish and dun-coloured slates crushed and cleaved. At the farther point are contorted red sandstones and slates.

PLATE VI.—Diagrams, Figs. 1 and 2, show the general relations of the rocks in Pl. V. to the coast section. Traps omitted.

FIG. 1. Supposing the limestone (1) the highest rocks of the district, the view maintained in the text.

FIG. 2. Supposing the limestone (1) to come between the groups (3) and (2*) *above* it, and slates (2) of Mudstone Bay *beneath* it, according to the received opinions of writers.

✢ The part 1* slightly enlarged. (4. Volcanic.)

FIG. 3. View near Woolacombe, North Devon (described in the text).

NOTE.—By tracing and retracing from my pocket-book sketch, the foreground has somewhat lost in effect. The curve is rather under- than overdrawn.

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## II.—GEOLOGICAL TIME.

By C. LLOYD MORGAN, F.G.S., A.R.S.M.

(PART II.)

(Continued from p. 162.)

IN passing on to the consideration of the rate at which the various strata were formed, it will be well, I think, to group the rocks under six heads. First, Mechanical deposits formed in deltas, lakes, and estuaries; secondly, Mechanical deposits along the shoreline, in large bays, or constricted seas, such as the German Ocean; thirdly, Chalk; fourthly, Coral Limestone; fifthly, Coal; and lastly, Volcanic Rocks.

I. With regard to mechanical deposits, it is obvious that they are the products entirely, or almost entirely, of subaerial denudation, although in the formation of the second group marine denudation aids to some extent. Our first duty, therefore, will be to gain some notion of the rate at which the land is wasting away under the influence of the weather, of rain, and of rivers. This subject has been carefully studied by Mr. A. Tylor, Mr. Croll, and Professor Geikie, and the study has been productive of most interesting results. But a slight study of the action of rain as an agent of denudation is necessary to make obvious the fact that the soil is gradually, and continually, washed down seawards; but that as fast as soil is carried away, fresh soil is formed by the action of rain and the weather. Only in steep and mountainous regions is the flow of water so rapid as to carry away the material abraded from the rocks, *directly*, without any formation of soil. Now all the material washed from the surface of the land is carried into the rivers. To ascertain, therefore, the rate of subaerial denudation in any area, we have only to find the amount of sediment transported by the rivers which drain that area. If we knew, for example, the exact amount of suspended matter which is carried into the sea by all the rivers of England, we could readily calculate the rate at which that country is yielding to subaerial denudation. At present, however, we have not the requisite data for making this calculation. The matter is much simplified if we take the cases of individual rivers, and calculate the rate at which they are lowering the average level of the area of country which they drain. This has been done for a few rivers, and the following table, from Professor Geikie's paper on this subject, shows the number of years which it would take, at the present rate of denudation, for each river named to remove one foot of solid rock (the average sp. gr. of river-silt being taken at 1·9 and that of rock at 2·5).

| | | | | |
|---|---|---|---|---|
| Mississippi ..... ..... ..... ..... | one foot in | | 6000 | years. |
| Ganges ..... ..... ..... ..... ..... | „ | „ | 2358 | „ |
| Hoango Ho ..... ..... ..... ..... | „ | „ | 1464 | „ |
| Rhone ..... ..... ..... ..... ..... | „ | „ | 1528 | „ |
| Danube ..... ..... ..... ..... ..... | „ | „ | 6846 | „ |
| Po ..... ..... ..... ..... ..... | „ | „ | 729 | „ |
| Nith ..... ..... ..... ..... ..... | „ | „ | 4723 | „ |

Taking the mean height of the American Continent at 1496 feet, at the present Mississippi rate of denudation that continent would be worn away in about nine million years. Asia, at the rate at which the Ganges destroys it, would disappear in five million years; and if the whole of Europe were denuded at the same rate as the basin of the Po, it would be levelled in rather less than a million of years.

But these calculations take no account of the material removed in solution by *Chemical* denudation. If this be taken into consideration, the figures above quoted will have to be considerably modified. Mr. T. Mellard Reade, in his Presidential Address to the Liverpool Geological Society, 1877, calculated that the general area of England and Wales was lowered by chemical denudation at the rate of ·0077 of a foot in a century, or one foot in 12,978 years. He also states that the matter in suspension in the waters of the Danube are in amount three times those in solution; but the solids in solution come down constantly; the mud is pushed along in times of flood. Certain experiments of mine on Thames water (taken from the river near the Waterworks, Surbiton) tend to show, that the matter in solution, even in time of flood, was seven times that in suspension, while in summer time this ratio was exceeded, and was more nearly twenty times. In these experiments, however, no account was taken of the solid matter *dragged* along the bottom. In the above calculations, therefore, of the rate at which the general surface of large areas is being lowered, we may fairly consider that the length of time mentioned as that in which the several rivers would remove one foot of solid matter may be reduced by, say, one-fifth, in some cases more, and in some, perhaps, less.

Let us now see the application of these facts. The area of the Mississippi basin is 1,147,000 square miles, that of the delta of the same river 12,300 square miles. Let us assume that the area over which deposit is now taking place is equal in size to the present delta, and let us assume that only three-fourths of the material swept off the Mississippi basin is thus deposited, the other one-fourth being carried far into the Gulf of Mexico. Then $\frac{1}{8000}$ of a foot is swept from the basin and deposited over, say, 12,000 square miles. This will form a deposit rather more than one-seventh of an inch thick. One-seventh of an inch per annum may therefore be taken to be the rate of deposit in the delta of the Mississippi. According to the estimates of Colonel Strachey, based on the observations of Mr. Everest, the rate of deposit is more rapid in the delta of the Ganges and Brahmapootra, amounting to more than one-fifth of an inch per annum, and this over an area of 65,000 square miles. The Po drains an area of about 30,000 square miles, and lowers that area $\frac{1}{729}$ of a foot every year. If we take the area of deposit at the mouth of the river at 1000 square miles, the rate of that deposit will be nearly half an inch per annum. To take one more case, excavations were carried on by Mr. L. Horner, in 1850, in the great plain of Memphis, to ascertain what thickness of Nile mud had been deposited there since the erection of the colossal statue of Rameses II. It was found that nine feet four inches of silt had accumulated since the foundations of the statue had been laid some 3211 years previously. This is at the rate of $\frac{1}{28}$th of an inch per annum. Thirty-two feet below the base of the pedestal the Nile mud was found to rest on desert sand, and close to the line of junction a fragment of burnt brick was discovered, which, if the rate of deposit was the same before the erection of the statue as since its foundations were laid, was 13,496 years old. The rate of deposit at Elephantiné, near the First Cataract, was estimated by Sir J. G. Wilkinson at nearly double that near Memphis, or about one-sixteenth of an inch per annum, while the high Nile has been known to cause a deposit one inch in depth for ten feet of water.

Taking all these facts into consideration, we shall scarcely err in excess if we estimate the average rate of delta deposition at one-tenth of an inch per annum. In taking the present rate of deposition as our standard, we are not likely to err in excess: for though in past ages the average amount of rainfall in our hemisphere may have been at some times less than the present amount, yet at other times, during periods of higher excentricity of the earth's orbit, for example, the amount was, probably, considerably greater.

With regard to estuarine and lake deposits, we have not many data on which to base any calculations. But I see no reason why these formations should not accumulate as rapidly as those in a delta. We will therefore take, hypothetically, one-tenth of an inch as the average rate of the accumulation of all this series of deposits.

II. In considering the rate of accumulation over such an area as the North Sea, for example, we find but little on which to base any calculations. Some of the rivers which fall into that sea, the Rhine and Scheldt, for instance, form great alluvial flats, while the finer and coarser materials brought down by other rivers are caught up by the tides which sweep by their mouths, and become far more widely scattered. The rate of deposit will be, then, in different parts of the area, very variable. But if we take the area of country which drains into the German Ocean at twice the size of that sea, and the rate of subaerial denudation to be one foot in three thousand years, we shall find that the *average* rate of deposit over the German Ocean is $\frac{1}{125}$ of an inch per annum.

Along the coast-line of a great continent the rate at which sedimentary deposits are formed will be still slower. A glance at a map of North America will show from how vast an area of that continent the Mississippi collects its waters. We have seen that the sediment borne by those waters is collected over a comparatively small area, in the neighbourhood of the Gulf of Mexico. Along all the eastern coast, from Labrador to Florida Straits, but little sedimentary deposit is being formed. If we take the strip of land which is drained into this portion of the Atlantic to be, on the average, two hundred and fifty miles broad, and the area over which deposit is taking place to be a strip extending for a hundred miles from the coast-line, and the rate of denudation to be the same as in the Mississippi basin, we find that the rate of accumulation is $\frac{1}{200}$ of an inch per annum. If again we turn to South America, we find that almost the entire drainage of the continent is eastwards. Taking the area which drains in this direction at about five and a quarter million square miles, the rate of denudation the same as in the Mississippi basin, $\frac{1}{6000}$ of a foot per annum, the eastern coast-line at about 8500 miles in length, and the zone of deposit to stretch one hundred miles from the shore-line, we shall find that in this area about $\frac{1}{80}$ of an inch of rock is deposited each year. We must remember that much of this sedimentary matter will be collected in the neighbourhood of the four great rivers, the Amazons, La Plata, Orinoco, and San Francisco. Altogether, then, we may consider that the rate of formation of mechanical deposits at a considerable distance from the principal foci—as we may call the delta, or estuarine areas—is not greater than $\frac{1}{100}$, or perhaps, $\frac{1}{200}$ of an inch per annum.

III. Professor Huxley, in his article on "Coral and Coral Reefs," quotes the following estimate of the rate of Coral deposit from Dana's Manual of Geology. "The rate of growth of the common branching Madrepore is not over one and a half inches a year. As the branches are open, this would not be equivalent to more than half an inch of solid coral for the whole surface covered by the Madrepore; and as they are also porous, to not over three-eighths of an inch of solid limestone. But a coral plantation has large bare patches without corals, and the coral sands are widely distributed by currents, part of them to depths over one hundred feet, where there are no living corals; not more than one-sixth of the surface of a reef region is, in fact, covered with growing species. This reduces the three-eighths to *one-sixteenth.* Shells and other organic relics may contribute one-fourth as much as corals. At the outside the average upward increase of the whole reef-ground per year would not exceed *one-eighth* of an inch."

IV. Professor Huxley, in his admirable lecture "On a Piece of Chalk," describes a specimen of *Micraster* in the Museum of Practical Geology, which aids us in forming some idea of the "period which must have elapsed between the death of the Sea-urchin, and its burial by the *Globigerinæ.* For the outward face of the valve of a *Crania*, which is attached to a Sea-urchin, is itself overrun by an incrusting Coralline, which spreads thence over more or less of the surface of the Sea-urchin. It follows that, after the upper valve of the *Crania* fell off, the surface of the attached valve must have remained exposed long enough to allow of the growth of the whole Coralline, since Corallines do not live embedded in mud." "If the decay of the soft parts of the Sea-urchin; the attachment, growth to maturity, and subsequent decay of the *Crania*; and the subsequent attachment and growth of the Coralline, took a year (which is a low estimate enough), the accumulation of the inch of chalk must have taken more than a year." Professor Huxley adds, "On any probable estimate—the Chalk period must have had a much longer duration than that roughly assigned to it," on the supposition that an inch of that rock could be formed in a year. Perhaps we may take it as probable that a period of twenty-five years would be sufficient for the changes to which the *Micraster* specimen testifies. If so, we have no evidence that chalk *may not* be accumulating at the rate of $\frac{1}{25}$ of an inch per annum. More than this, in the present state of our knowledge, we cannot say.

V. With regard to Coal, Principal Dawson says that "we may safely assert that every foot of thickness of pure bituminous coal implies the quiet growth and fall of at least fifty generations of *Sigillariæ*," so that if we follow Professor Huxley in the moderate supposition that "each generation of coal plants took ten years to come to maturity—then, each foot thickness of coal represents five hundred years," or the material accumulated at the rate of a little more than $\frac{1}{40}$ of an inch per annum. Principal Dawson's assertion, however, has reference to American coal, which is formed of the accumulated stems of trees, but "undoubtedly the force of these reflections is not diminished when the bituminous coal, as in Britain, consists of accumulated spores and spore cases, rather than of stems," and therefore we may fairly consider that $\frac{1}{40}$ of an inch is a high estimate of the rate of accumulation of coal, and that perhaps $\frac{1}{100}$ of an inch would approximate more closely to the truth.

VI. I do not remember to have seen any definite calculations of the rate of accumulation of volcanic rocks, nor indeed is this to be wondered at, since the formation of volcanic products is both local in character and spasmodic in its mode of action. It will, however, be useful to consider a few instances of volcanic accumulation, which will show that in some cases the rate of this accumulation may be comparatively rapid. Sir Charles Lyell, in 1828, measured the thickness of volcanic ash which covered the town of Pompeii, near the amphitheatre, and found it to be ten feet three and half inches, which gives a rate of accumulation of rather more than one-fifteenth of an inch per annum. Over Herculaneum, which is nearer to Vesuvius, there has accumulated a thickness of from 70 to 112 feet of material, giving since A.D. 79 a rate of accumulation of some two-thirds of an inch per annum. After the eruption of Coseguina in 1835, "eight leagues to the southward of the crater, the ashes covered the ground to a depth of three yards and a half," so that, if we suppose such an event to happen once in 1800 years, the rate of accumulation of this material over that spot would be one-tenth of an inch in a year. With regard to lava, the well-known eruption of Skaptar Jocul in 1783 poured forth two streams, of which one was fifty miles in length, with an extreme breadth of some fifteen miles; while the other was forty-five miles in length, with an extreme breadth of seven miles, the average depth of each being one hundred feet. If such an eruption, or minor eruptions equalling it in the amount of material emitted, took place once in every *twelve hundred* years, the average rate of deposit would be one-tenth of an inch per annum, and this without taking into account the immense volume of ash shot forth from Skaptar Jocul during the same eruption of 1783. Beneath the waters of a sea, in the neighbourhood of a frequently active volcano, a deposit of volcanic ash may form with comparative rapidity, while the rate of growth of the volcano itself would be still greater. The highest marine clays on the flanks of Etna are some 1258 English feet above the level of the Mediterranean, and within them are contemporaneous basaltic products, "the most ancient monuments of volcanic action within the region of Etna." The total height of the mountain being 10,874 feet, we may take it that of this, 9616 feet are due to volcanic accumulations. Let us take 4500 feet as the average height over a large area, say some 400 square miles. Then, if the mountain began to accumulate, as Sir Charles Lyell supposes, at the time of the Norwich Crag, and if this period may be placed, on Mr. Croll's estimate, some 270,000 years ago, then the rate of the accumulation of the volcanic products of Etna must have averaged about one-fifth of an inch per annum. In the absence of data of any certainty therefore, we may take $\frac{1}{25}$ of an inch per annum as the rate of volcanic accumulation.

Let us, now, take the thickness of the rocks at the liberal figure of 100,000 feet. And let us suppose that of these 50,000 ft. were deposited at the rate of $\frac{1}{100}$ of an inch per annum, and of the remaining rocks, 25,000 were laid down at the rate of $\frac{1}{50}$ of an inch per annum, and 25,000 were formed in delta or analogous deposits at the rate of $\frac{1}{25}$ of an inch per annum; then the time occupied in the deposition of 100,000 feet of rock would be eighty-two and a half millions of years. Seeing therefore that, in the first place, 100,000 feet is probably too high an estimate of the average thickness of the rocks from Laurentian times to the present; that, in the second place, those rocks should be more properly arranged in two or three parallel series than in one long column; that, in the third place, the rate of deposit, on which the calculation is made, is sufficiently small; and that, lastly, on the evolution hypothesis, there is some probability that, in old geological times, the strata were formed more rapidly than in these latter days, is there any reason why geologists should hesitate to accept 100,000,000 years as the limit of geological time? Nay, for my own part I shall not, on geological grounds, feel very uneasy if more certain physical results than have already appeared limit the age of the rocks to fifty millions of years.

An attempt has been made by Mr. T. Mellard Reade to estimate the geological age of the earth by the amount of chlorides contained in solution by sea-water. "Reckoning all the chlorides annually brought into the sea at eight tons to the square mile, it would take," he says, "in even numbers, two hundred millions of years to renew the chlorides of the sea." How far these figures may be correct it is not easy to say. We have at present but few data bearing upon the subject. But supposing, with Mr. Reade, that it would take, *at the present rate,* two hundred millions of years to restore to the sea its saline constituents, then, taking into consideration the exceedingly soluble nature of these chlorides, and the high probability that in ancient geological times, when the earth was younger, these materials were washed seawards far more rapidly than is at present the case, it would seem a fair conclusion that from sixty to one hundred millions of years have been amply sufficient to render, by these means, the sea as salt as we now find it.

"But it may be said," writes Professor Huxley, "that it is biology, and not geology, which asks for so much time—that the succession of life demands vast intervals; but this appears to me," continues the Professor, "to be reasoning in a circle. Biology takes her time from Geology. The only reason we have for believing in the slow rate of the change in living forms is the fact that they persist through a series of deposits which, Geology informs us, have taken a long while to make. If the geological clock is wrong, all the naturalist will have to do is to modify his notions of the rapidity of change accordingly." Professor Young, also, in his Presidential Address, British Association, Section C., speaks of Biologists "who, apparently unconsciously, seek to gain, by prolonging the interval between successive groups the time which ought rather to be sought for in tracing, were that possible, the migrations of the species which seem to have suddenly died out."

The biological aspect of Geological Time is, however, in my opinion, that which most authoritatively prevents us from accepting the "ten or fifteen million of years" which is all Professor Tait's mathematics will grant to his fellow-labourers in another branch of Science. The evolution of plants and animals (and this is now the only tenable hypothesis of their being) demands time for its fulfilment. 1. In the Wealden Delta deposits we find remains of Pterodactyles, reptiles with a highly specialized system of flying apparatus. 2. As far back as the Triassic epoch, Mammalia, Reptilia, and perhaps true Aves, had been evolved. 3. In Carboniferous times we find that Amphibia with an elaborate dentition (Labyrinthodonta) were in existence and continued without any important modifications until the era of the Trias; some three or four species of Reptiles have been found; and there are representatives of the highly differentiated invertebrate class, Insecta. 4. In the Upper Silurian rocks are the remains of well-developed fish, of Echinodermata (Star-fish), and of a host of Crustacea; while the fossils of the Lower Silurian epoch (especially the Trilobites) were by no means of the lowliest type.

With regard to the Cambrian rocks, "after quoting Professor Huxley's enumeration of the many classes and orders of marine life (identical with those still existing), whose remains characterize" those rocks, Professor Ramsay writes: "The inference is obvious that in this earliest known varied life we find no evidence of its having lived near the beginning of the zoological series. In a broad sense, compared with what must have gone before, both biologically and physically, all the phenomena connected with this old period seem to our minds to be quite a recent description, and the climate of seas and lands were of the very same kind as those which the world enjoys at the present day."

All this points to a long period of evolution, although, as Professor Huxley truly remarks, that period is measured by the geological clock. We must not however imagine that organic change has been throughout all time uniform in its rate of progress. Climatal changes—alternate periods of perpetual spring and bitter glaciation—and geographical changes in the limits of continental and oceanic areas—now allowing the fauna to multiply freely and expand, now reducing stage by stage a zoological area, and causing the struggle for life to be waged more fiercely—must have caused modification to have at times proceeded with much greater rapidity than we now see around us. But still the "great Phantom of geological Time" rises before us, "springing irrepressibly out of the facts," to use a metaphor of Professor Huxley's, "like the Djin from the jar which the fisherman so incautiously opened, and like the Djin again, being vaporous, shifting and indefinable, but unmistakably gigantic." We may not yet be able to read the time accurately by our geological or biological clock, but that clock for all that is no plaything.

There is one more aspect of this great question which remains to be considered. We have seen that there is a theory to account for the cold of the Glacial epoch, on the supposition that it was during periods of great excentricity of the earth's orbit that the glaciation took place. If then we could ascertain at what period the excentricity which produced the Glacial epoch occurred—if this hypothesis be correct—we could tell the length of time which has elapsed since that period, and should thus possess a standard to which we could refer other geological periods.

Within the last hundred thousand years there have been two periods of great excentricity. The former of these began 980,000 years ago, and terminated 720,000 years ago: the latter began some 250,000 years ago, and ended about 80,000 years ago. Sir Charles Lyell at one time referred the Glacial epoch to the former period, but subsequently agreed with Mr. Croll in assigning 250,000 years ago as the more probable date of the commencement of the Great Ice Age. According to this view, Mr. Croll calculates that sixty millions of years have elapsed since the beginning of the Cambrian period, whereas on the hypothesis that the Great Ice Age occurred during the former period of excentricity, the beginning of the Cambrian period will have to be placed, on the same method of reckoning, two hundred and forty millions of years back. But this, both the results of physical inquiry, and the known facts of denudation, declare to be improbable or impossible, while that a period of eighty thousand years should have elapsed since the Glacial epoch accords well with the amount of denudation which the Glacial deposits are found to have undergone. On this subject Mr. Croll writes as follows: "Now if we assign the Glacial epoch to that period of high excentricity beginning 980,000 years ago, and terminating 720,000 years ago, then we must conclude that as much as 120 feet must have been denuded off the face of the country since the close of the Glacial epoch. But if as much as this had been carried down by our rivers into the sea, hardly a patch of Boulder-clay, or any trace of the Glacial epoch, should be now remaining on the land. It is therefore evident that the Glacial epoch cannot be assigned to that remote period, but ought to be referred to the period terminating about 80,000 years ago. We have, in this latter case, thirteen feet, equal to about eighteen feet of drift, as the amount removed from the general surface of the country since the Glacial epoch. This amount harmonizes very well with the direct evidence of geology on this point. Had the amount of denudation since the close of the Glacial epoch been much greater than this, the drift deposits would not only have been far less complete, but the general appearance and outline of the surface of all glaciated countries would have been very different from what they really are."

It is not without great diffidence that I have written this article. In it I have rather aimed at giving a general *résumé* of a great subject, than attempted to add anything very new. Such as it is, I lay it before the readers of the Geological Magazine.

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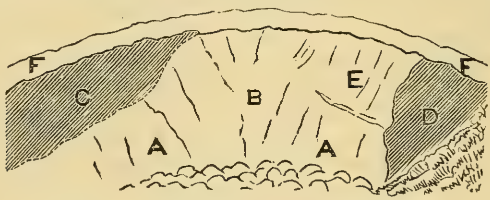
## III.—Note on the Felsite of Bittadon, N. Devon.

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

In his important paper on the Physical Structure of West Somerset and North Devon (Quart. Journ. Geol. Soc., vol. xxiii. p. 568), Mr. Etheridge incidentally refers to a felstone at Bittadon, saying of it (p. 609): "There is no proof that the igneous rock at Bittadon is eruptive." At the time when these words were written, it was undoubtedly impossible, from the nature of the exposure, to decide whether the rock was intrusive or interbedded; but, on visiting the locality in September, 1876, I found that a small quarry (for road metal) had been opened in the felstone, and its relations to the sedimentary rocks were pretty clearly exposed.




SECTION IN STONE PIT, NEAR BITTADON.

A, A Felsite.
B *Ibid.*, decomposed.
C Fine Slate.
D Fine Slate, much crushed.
E Quartz vein.
F, F Soil, Ground rising above.

The annexed diagram will, I think, render a long description needless. The junction on the right-hand side is very clear, and the slate a little below seems much crushed; on the left hand side the exact line of junction is not quite so easy to trace, as the felstone becomes much decomposed near it, but it is very nearly represented by the dotted line. The rock on this side is a hard grey rather lustrous slate, apparently dipping towards the S.E., with cleavage dipping at about 80° in the same direction, or perhaps rather more to the south. The felstone then is evidently not interbedded, but intrusive.

I have examined the rock microscopically; and as its structure is a little unusual, may complete this note by a short account of it.

Its ground-mass is compact in texture, and a dull greenish grey in colour, rather thickly studded with small felspar crystals, commonly from 0·1 to 0·2 inch long, of a reddish white colour; the majority certainly being orthoclase. A few small grains of quartz are visible. Here and there are brown ferruginous spots, apparently occupying the place of some of the felspar, and the whole rock has a decomposed aspect. It is also affected slightly by cleavage. Thus, in a hand specimen, it is not easily distinguished from a highly altered volcanic ash, such as might be found in the Borrowdale series of Cumberland. A slide, examined with a $\frac{1}{4}''$ objective, shows the ground-mass to be rather variable; in parts it is crowded with indistinct colourless microliths, brownish and greenish granules, and occasional black specks; in others it is irregularly banded with pale yellowish-green streaks. This last, on examination with both Nicols, proves to be one of the minerals provisionally classed as viridite; that exhibiting an irregular aggregate structure, and being feebly double-refracting. The colourless part of the ground-mass is now seen to be almost wholly made up of irregular rather fibrous microliths, bright-coloured with crossed Nicols. Here and there are rounded patches, less transparent than the rest, and minutely granular in structure, the transparent parts of which also show bright specks with crossed Nicols. There are many dark-brown ferruginous stains (some rather resembling altered ilmenite), a few small quartz grains, and numerous felspar crystals. Most of the last are orthoclase, rather resembling sanidine, but plagioclase is also present. They have often ragged edges, and a broken or crushed aspect, are sometimes almost opaque from ferruginous stains, and contain minute ferruginous microliths. In one or two of the larger crystals irregular groups of ill-defined microliths are included, resembling a devitrified glass,—possibly these may have once been glass enclosures, —also rather irregular aggregates of viridite (? replacing magnesia mica). The quartz is pretty clear, but here and there it contains a few extremely small microliths, and perhaps cavities.

The structure of the rock, both macroscopically and microscopically, is remarkable, as it bears considerable resemblance to that of some of the streaky ashes including broken felspar crystals from the Borrowdale rocks of Cumberland. In the field, however, I had no doubt of its nature, and, after many careful examinations of the slide, I feel convinced that the resemblance is accidental. Originally, it was probably a sanidine trachyte (there is hardly enough free quartz for a rhyolite) with a rather variable base, imperfectly microcrystalline or crowded with ill-defined microliths (perhaps not very unlike some of the Drachenfels trachyte). A slight amount of brecciation may have been produced by motion just before complete solidification, and subsequent pressure may have further crushed the rock; after which the original minerals have undergone considerable alteration.

From its appearance I should imagine that this rock had solidified at no great depth. It is intrusive in the "Grey Unfossiliferous Slates" of Etheridge—upper part of Middle Devonian—near their junction with the succeeding Pickwell Down Sandstones (Upper Devonian), and is affected by cleavage. Its intrusion must accordingly be prior to the close of the Carboniferous Period, when the cleavage was produced, and so probably happened some time towards the end of the Devonian Period.

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## IV.—Erratics at High Levels in North-Western America—Barriers to a Great Ice-Sheet.

By George M. Dawson, F.G.S.,
Geologist to H.M. North-American Boundary Commission.

In the last edition of his *Great Ice Age* (1877), Mr. Geikie has noticed at some length my descriptions of the glaciation and superficial deposits of the central region of North America, from Lake Superior to the Rocky Mountains;[1] giving an outline of the facts recorded, and of the explanation of these facts which I have ventured to present as that which appeared to me most probable. In one respect, however, some misapprehension seems to have

[1] Quart. Journ. Geol. Soc., Nov. 1875; also Geology and Resources of the 49th Parallel.

arisen, probably from my omission to explain the circumstances at sufficient length. As Mr. Geikie's work is deservedly referred to as an authority on the Glacial Epoch, I would here offer a few remarks in additional explanation of the point in question.

In the vicinity of the forty-ninth parallel, boulders from the Laurentian Axis, a great highland plateau, are distributed westward or south-westward across the whole breadth of the Great Plains to within twenty-five miles of the Rocky Mountains, where the country has an elevation of about 4,200 feet. *Débris* from the Rocky Mountains at the same time passes far eastward across the plains, the drifts of diverse origin overlapping to the extent of several hundred miles. The general inclination of the plain is eastward, or north-eastward, toward the foot of the Laurentian Axis, along which Winnipeg and associated great lakes lie, with an elevation of about 700 feet only. The higher parts of the Laurentian Axis have an average height of about 1600 feet.

If it be supposed that the western boulders were deposited in their present position by glacier-ice formed on the Laurentian Axis, or flowing over it from the north (as Mr. Geikie thinks most probable), the ice-sheet must have been pushed up-hill for a distance—measured from the Laurentian Axis—of about 700 miles. Many facts stated in the paper above referred to, but which cannot here be detailed, lead me to believe that the boulders in question reached their present position attached to sea-borne ice. Mr. Geikie, in objecting to this hypothesis, writes:—"When we remember, however, that the maximum height of the latter (Laurentian Axis) is only some 1600 feet, we may well ask how these boulders could possibly have been carried by floating-ice; for, when the sea stood at the level of 4200 feet, the Laurentian Axis, from which the boulders have come, must have been drowned to a depth of 2,400 feet, at least!"[1]

This difficulty, though at first sight a very grave one, was not ignored. I believe the evidence to be conclusive, that the western portion at least, of the Laurentian region, was covered by a confluent glacier, guided in the direction of its motion by that of the general slope of the surface, but impelled chiefly by the pressure resulting from the continual addition of snow and ice to its central and higher portion. Pre-supposing this, I have written:[2] "The occurrence of Laurentian fragments at a stage in the subsidence, when, making every allowance for subsequent degradation, the Laurentian Axis must have been far below water, would tend to show that the weight and mass of the ice-cap was such as to enable it to remain as a glacier, till submergence was very deep." By this it was intended to suggest that a ponderous ice-cap, several thousand feet in thickness, continually reinforced by abundant snow-fall, might continue to act as a glacier till the surrounding water gained on it to such an extent as to float it bodily away. To this I might have added as an additional, and perhaps more probable suggestion,

[1] Great Ice Age, p. 472.
[2] Quart. Journ. Geol. Soc., 1875, p. 622.

that adopted by Principal Dawson to explain the transport of blocks of sandstone from the Cumberland plains of Nova Scotia to the summits of the Cobequid Hills, viz. that the ice-fields of successive years may have raised these erratics and deposited them at higher and higher levels, during a more or less rapid subsidence of the land.[1] This process is at least competent to effect the result, and wherever coast-ice surrounds a sinking shore, the materials of the beach must thus be gradually warped up, though but a small proportion of the material from below could ever reach a great height.

It is probably to action of this kind that Darwin wishes to appeal in endeavouring to explain the positions of erratics in some parts of England, though I only know his views by a reference to them by Mr. Geikie, in a note on the same subject read by him before the Geological Society of Glasgow in 1873, and in part reprinted in the Great Ice Age; in which it is endeavoured to explain the facts by the forcing up in the mass of a glacier, owing to "frontal resistance" of stones included in it.

To my mind, many facts seem to show the impossibility of the westward extension of a vast ice-sheet from the Laurentian Axis across the plains. The most striking of these is perhaps the existence of the great escarpment of soft Cretaceous rocks, which runs parallel with the south-western base of the Laurentian, at an average distance of 130 miles from it; the Winnipeg group of lakes occupying the intervening low ground. There are gaps in this escarpment, the most extensive being the valley of the Assineboine; but, in the main, it extends from near the Saskatchewan River to the forty-ninth parallel, with a bold north-eastern front, and a height in some places of 900 feet above the low country occupied by the lakes. That any mass of glacier-ice should have been forced across this escarpment without destroying it, seems incredible; though that the Laurentian Glacier may have reached its base in places appears not improbable.

The wide valley occupied by the Winnipeg group of lakes and Red River has doubtless, in the first instance, been formed by river-erosion. A great stream at one time probably flowed southward in it,[2] gradually cutting downward, and shifting its channel westward on the sloping surface of the hard Laurentian rocks, at the expense at first of the soft Cretaceous strata, and later of the Devonian and Silurian limestones. The valley is pre-glacial, and, with the escarpment, has been produced in this way precisely in the manner explained by Professor Ramsay in describing the formation of the Weald of Kent and Sussex.[3] A like process may also account, to a great extent, for the production of the valleys now occupied by the Great Canadian lakes, and of those of Athabasca, Great Slave, and Great Bear Lakes in the far North-west; all of which hold a similar position with regard to the Laurentian region, and overlying newer and little-disturbed rocks.

[1] Acadian Geology, p. 65.
[2] Geology and Resources of the 49th Parallel, p. 253.
[3] Physical Geology and Geography of Great Britain.

Quite lately, Prof. E. W. Claypole, of Antioch College, Ohio, in connexion with the theory of an all-powerful ice-sheet, has drawn attention to the well-known great Silurian escarpment, which bears a similar relation to the Laurentian Highlands in the Peninsula of Ontario, and northern part of Lake Huron, and consists of a range of cliffs in some places 200 to 300 feet high. Prof. Claypole writes:[1] "It appears as if geologists who advocate the excavation of the basins of the great lakes by the action of northern ice flowing off the Laurentian Highlands are somewhat oblivious of the existence of this escarpment. If the ice possessed the enormous eroding power on rocks and cliffs so often attributed to it, it must certainly have cut away and destroyed this gigantic barrier to its advance before proceeding to scoop out deep basins to the southward."

In discussing these points it is necessary to assume that the relative elevation of different parts of the continent have remained unchanged during and since the Glacial period. This is probably not strictly true, and may be so far from correct in some cases as to invalidate arguments based on the assumption. Unequal elevation, great in amount, must have occurred in the west toward the close of the Tertiary, and may have continued in progress in Glacial, or even in post-Glacial times.

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## V.—Denudation—Rain and River.

By Henry O. Forbes, Esq.

DURING a recent residence in Portugal I paid a visit in Feb. 1877, to Coimbra, and while standing on the tower of the University, whence a magnificent view of the surrounding country can be obtained, I was much struck by the immense accumulation of sand deposited over a wide area on both banks of the river Mondego, by whose margin the city stands. A considerable, though, comparatively speaking, a small quantity was of recent date, and was evidently brought down by the heavy rains in the months of November[2] and December of the previous year, which had produced destructive floods throughout the country, and had here greatly threatened the low-lying parts of the town. I was informed that every year a large quantity of new sand is spread out over the valley ; but the shortness of my stay here precluded any attempt to estimate the yearly additions to the fluviatile stratum.

Since my return to England, however, I have fallen on some interesting notes, geologically speaking, in various old Portuguese works, which I send you, as they afford, I think, an approximate estimate to the amount of denudation in a known period.

When the Alani overran the Peninsula in the fifth century, their king Ataces captured from the Suevi the town named by the Romans Conembrica—the spot now bears the name Condeixa a Velha. It seems to have suffered so severely in the struggle that the erection of an entirely new city was resolved upon on the mag-

[1] Canadian Naturalist, vol. viii., No. 4, p. 197.

[2] Cf. Meteorological Notes from Lisbon, *Nature*, vol. xvi. 1877, p. 265.

nificent site of the present Coimbra; and ere long the steep slope was clothed with buildings down to the water's edge. Among other works Ataces built a bridge over the river, "probably of one arch, as the river was narrower and very deep." In 1132, this structure having perished beneath the sand, a second was ordered to be erected over it by Count Affonso, in whose person the monarchy of Portugal was soon after established; and the historian further relates, "that in the first years of the monarchy, during which the Count resided in Coimbra, fleets of ships, men of war, and galleys of great size (de grandeza Capaz) came up from the mouth as far as the city, for the river did not then overflow its banks so much nor bring down so much sand as now" [1600-1650]. "Its waters," he adds too, "when kept for some time, though sharp, were not unpleasant to the taste; but their effect on the complexion, or if used in confections for the face, are most prejudicial, because they spoil the skin and make it to wrinkle too soon." This, if fact, would lead us to suspect some chemical impurity in the water, which was not, however, injurious to animal life, for we are further informed that "there was good fishing in the river of chad, lampreys and eels." The *aguadeiras*, or water carriers, of the present day, must be ignorant of its injurious properties, or disregard them, for I saw them busily engaged in carrying it into the town for household purposes. The sage historian attempts no explanation of the facts he asserts, as he is "simply a recorder, and knows nothing of medicine." I was unaware of this peculiarity in the water at the time, otherwise I should have obtained some for analysis. I hope, however, to hear in a short time from my friend Dr. Paulino d'Oliveira, Professor of Analytical Chemistry in the University, the result of his examination, and whether there is any gold to be found now in the sand, for "anciently there was much gold taken out close to the river; and at the top of Pena Cova, there are in many places evident signs whence it has been been got out, and many heaps of stones which the workers have collected."

In 1438 Affonso V., alarmed at the ravages made by the river, which had before this carried away many of the low-lying houses built by Ataces, and ruined the monastery of Santa Clara on the northern bank, prohibited under heavy penalties the clearing of the undergrowth from the banks for a distance of a league on each side between Cea, at the foot of the Estrella Mountains, and Coimbra. The farmers, however, envious of the rich harvests which could be grown there, by and bye disregarded with impunity this law, and burned down the vegetation which checked the progress of the sand, ploughed and cultivated the lands much to their own advantage, but to the irrevocable devastation of the valley for their successors.

In 1513, the bridge of 1132 having almost disappeared, a third was added to the two already swallowed up, which has in time sunk down to give place to the goodly structure now uniting the two banks.

At present nearly the whole plain is covered with sand from Coimbra to the sea; while year after year recently fertile fields are being converted into sandy wastes. The depth of the river, too, is yearly decreasing, and can to-day float only light flat-bottomed boats.

During the rainy season in November, I resided in Lisbon; and took advantage of the first fair day—a fortnight after it had set in—to visit the soft red sandstone cliffs on the south bank of the Tagus, facing the town, and forming the south-western boundary of the large bay into which the river expands. Here the amount of denudation must have been thousands of tons. The whole front of the cliffs had suffered severely, as the *débris* at the fort and the red colour exhibited by the river for ten or twelve days previously testified; but in many places quarry-like excavations had carried the head of the cliffs back some ten to fifteen feet for a length of several yards. A little distance inland, at a spot where the road runs between cliffs, of the same sandstone, of 50 to 60 feet in height, a similar effect had been produced. Here nearly a hundred blocks of various sizes were lying at the foot among a mass of disintegrated sand, trees and shrubs. I give the measurement, in mètres, of one of intermediate size, and of roughly triangular shape: length, 2·4; thickness at base, 1·5; at apex, ·5; average height, 2·4. The amount of denudation for the rest of this wet season must have been very great, when so much was accomplished in one short fortnight.

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## VI.—The Fossil Fish Localities of the Lebanon.

By the Rev. E. R. Lewis, M.A., F.G.S.,

Professor in the Syrian Protestant College, Beirût, Syria.

If an apology were needed for writing a few words upon the subject of the fossil fish of the Lebanon, mine would be this, that I have resided so near the well-known localities as to be able to visit them often and collect more and better specimens than have ever been found there before. Many and celebrated geologists and palæontologists have written upon the subject of the fossil fish found here, and yet the localities have been visited by few of those who have written best. The distinguished palæontologist F. J. Pictet published a volume in 1850,[1] and another, together with M. Alois Humbert, in 1866,[2] in which are found interesting histories of the localities Hâkel and Sahel Alma, and most excellent and accurate descriptions and figures of the fossil fish found there up to the last date mentioned. But for four years I have been receiving specimens from Sahel Alma, and nearly as long from Hâkel, and now have all the specimens mentioned or described by M. Pictet with a difference. Where he had, in many cases, imperfect specimens, I have now, in all cases, superb examples; where he spoke only by name, of species described by Costa and others, of which he

[1] Description de quelques Poissons Fossiles du Mont Liban, par F. J. Pictet. Genève, J. G. Fick, 1850.

[2] Nouvelles recherches sur les Poissons Fossiles du Mont Liban, par F. J. Pictet et Aloïs Humbert. Genève, H. Georg, 1866.

had not seen examples, I have the species mentioned, which are, in some very few cases, identical with species described by himself under other names. But over and above all this, I have in my collection several new and undescribed species. The possession of so many interesting specimens has led me to study the subject with care and interest, and to visit the localities from time to time, until now I am induced to write a few words upon a subject of much interest historically and geologically.

M. Pictet never visited the localities of the Lebanon in person, and his confrère, M. Humbert, did so at a most unfavourable time, namely, at the time of the massacres in 1860. M. Louis Lartet did not visit the localities, at any rate he quotes Botta and Humbert in speaking of the places; although he was himself, at one time, within an hour of Sahel Alma, when, in 1864, he visited the Dog River caverns.[1] He evidently did not know how near he was to the fossil fish locality, or perhaps was too much interested in his archæological investigations and discoveries. He gives, however, valuable hints respecting the neighbouring geological formation, and confirms M. Botta's observations in part. Dr. Fraas did not go so far north when he collected his valuable notes, which he has since published.[2] His book, however, has thrown much light upon the geology of Palestine, and will be of help, indirectly, in settling some of the questions respecting the age of the geological formations in the Lebanon. He has visited the Lebanon more recently, and will undoubtedly add much valuable information when he publishes a second edition of his work. He has kindly sent me some of the figures of new species found at Hâkel, examples of which are in my own collection also. He writes me, in acknowledgment of a few photographs which I sent him of new species from Sahel Alma, "But by far the most important specimens you have photographed are the Selachians, especially the Rays, which excel anything hitherto known of this group. The remains published by Pictet are poor specimens compared with your remarkably fine series." I shall defer writing upon the subject of the fossil fish themselves until a future article, and content myself now with writing concerning the localities, my visits to which have given me an acquaintance with facts of considerable interest. But I do not think it will be amiss to give, in English, as introductory to what I may hereafter write, something of the history of these localities, be it ever so briefly, before mentioning what I have discovered during my visits to them. I am indebted, for the suggestions of various authors, and to M. Pictet, although I have verified the references, and corrected one or two unimportant errors into which he fell.

The first mention of the existence of fossil fish in the Lebanon is found in Joinville's "Histoire de St. Louis," edited by M. Natalis de Wailly, page 270. During the sojourn of the King at Sidon in 1253,

[1] Exploration géologique de la Mer Morte, de la Palestine et de l'Idumée (p. 217), par Louis Lartet. Paris, Arthus Bertrand, no date.

[2] Aus dem Orient von Dr. Oscar Fraas. Stuttgart verlag von Ebner und Seubert, 1867.

just before his return home from the Crusades, a stone was brought him, says Joinville, "which was the most marvellous in the world, for when a layer of it was lifted, there was found, between the two pieces, the form of a fish. The fish was of stone, but lacked nothing in form, eyes, bones, colour, or anything necessary to a living fish. The king demanded a stone and found a tench within."

Of course it is impossible to tell what species was shown the King, and it may seem idle to hazard a guess; but the specimen was most probably from Hâkel, since that was the locality first known; M. Maraldi mentioning it in a letter to the "Academie des Sciences" of Paris, in 1703, and M. C. Lebrun again in 1714, while neither mentions Sahel Alma. Besides, the historian speaks of a stone composed of layers which opened, a description applicable to most of the specimens brought from Hâkel, but rarely true of those from Sahel Alma. In that case the specimen was most probably a *Clupea*, since that is the genus found on the surface at Hâkel; and it might very easily be called a tench by a casual observer. It may seem foolish, and of course unscientific, to deal in speculations like these, but one seems led to it when reading of fossil fish collected 625 years ago.

M. de Blainville, so far as is known, was the first to attempt a scientific determination of the Lebanon fish, and he, in 1818, described *Clupea brevissima* and *Clupea Beurardi* from Hâkel.

Agassiz, in his celebrated work, 1833-43, described *Clupea lata*, *Clupea minima*, from Hâkel, and *Sphyræna amici* and *Rhinellus furcatus* from Sahel Alma. He very singularly figures the *Rhinellus*, vol. ii. tab. 58[b], fig. 5, and gives fig. 6 as a fragment of the same species, when it is, in reality, a *Dercetis*, a genus figured in the same volume, tab. 66[a], fig. 1 and 2, though the species may possibly be different. The next Lebanon specimen described was by Sir Philip Grey Egerton, Quart. Journ. Geol. Soc., 1845, vol. i. page 225, the *Cyclobatis oligodactylus* from Hâkel.

Then Haeckel followed in 1849, adding the genus *Pycnosterinx*, two species, and a new species of *Clupea*, the former from Sahel Alma, and the latter from Hâkel; then O. G. Costa, "Descrizione di alcuni Pesci fossili del Libano," 1855, added the genera *Imogaster* and *Omosoma*, and described a *Beryx*.

Finally, in 1866, appeared the valuable work of Pictet and Humbert, above referred to, which figures and describes, or refers to, 26 species from Sahel Alma, 21 from Hâkel, and four of doubtful origin; in all 51 species, if all be allowed, which is a matter of doubt, since M. Pictet was in some uncertainty about the identity of one or two species described by Costa, one described by Haeckel, and two, at least, to which Agassiz referred only, without figuring and describing. In these cases M. Pictet enumerates all the species mentioned as distinct species, and describes his own examples under different names. Examples of this will be given in another article.

M. Lartet, in the work previously cited (page 109), adds a new *Clupea* to the eight or nine previously described. I can but think that these species will be reduced in number when a large collection from Hâkel has been systematically examined. In mentioning the above I do not include the species known by teeth only or by single scales. M. L. Lartet speaks of a scale found near Hasbeya in the Anti-Lebanon, teeth of *Lamna* from Neby Musa (page 111); and Dr. Fraas (Aus dem Orient, page 109) refers to teeth, etc., collected by Dr. Roth near Jerusalem, and identifies four species. My remarks here are confined to Lebanon localities, of which the number hitherto known is two, Hâkel and Sahel Alma, and these will be described further on; but during this last summer I visited a new locality which I have never seen mentioned. It is called Hazhûla (Djoula on the French military chart). It lies nearly south of Hâkel, and distant from it about two hours and a half over a wretched road. The locality is in the outskirts of a most miserable Metawali village, and the rock a friable limestone, which, in many of the specimens, is very pulverulent, breaking into thin layers and crumbling to pieces when the specimen is trimmed with the hammer. At least, such is the case with most of the specimens which have been exposed to the atmosphere a long time, as had those which I collected. The species are the same as those found at Hâkel, but certain parts are better preserved. I obtained there several specimens of *Aspidopleurus cataphractus*, Pict. et Humb., with the singular scales of the species beautifully preserved. I am not certain that I have obtained any of this species at Hâkel, and, since I have had several hundreds of specimens from Hâkel, including all the known species, I have queried whether the specimen described by Pictet came from Hâkel, and was not rather brought to Hâkel from Hazhûla. The species at any rate is rare at Hâkel. At Hazhûla, I obtained five examples during my short stay. Besides this species, I obtained several specimens of *Eurypholis Boissieri*, Pict.; *Beryx vexillifer*, Pict.; *Cyclobatis oligodactylus*, Egerton; several *Clupea* of various species, and two or three kinds of Crustacea. I was able to be in the place only two hours, and was sufficiently annoyed in that time by the clamour for "backsheesh," and the demand made by twenty at a time to buy whatever was offered. But in the short time I was there, and notwithstanding the unfavourable circumstances in which I was placed while there, I obtained about fifty good specimens picked up from road and hill-side. The exact place from which the stone came was very near by, but I did not see and examine it, so excited and clamorous did the ignorant fanatical people become, threatening to break all I had collected, frightening my muleteer, etc., etc., led on by a few who pretended that I was seeking treasures. It required considerable tact and a great waste of Arabic to get off with my donkey load of specimens, and as it was, I had to send the muleteer ahead, and bring up the rear myself with a faithful attendant. The locality is an interesting one, and I shall revisit it as soon as possible.

I have said that Hâkel is the oldest known locality, though it has been rarely visited. I know of none who have visited it except M. Humbert, and recently Dr. Fraas. The former, only, has published anything concerning the place. It can be reached in one hard day from Beirût. We follow the sea-coast to Jebail (the ancient Byblus), a small seaport town between Beirût and Tripoli, then strike N.E., over the *débris* of old and ruined temples and towers which once covered the place towards Amshît, leave it on the left, and turn nearly east, following the windings of a ridge which looks abruptly down upon deep valleys on either side. The road is at first covered with fragments of limestone, abounding in cavities, and, in places, composed almost entirely of *Nerinœa abbreviata*, Conrad, and *N. mamillœ*, Fraas, all very large specimens; but soon this ceases, and the road passes over an almost horizontal stratum of unfossiliferous limestone, much resembling, in general appearance, the limestone slabs from Hâkel. The travelling soon becomes slow and tedious. The road is bounded by stone walls, which limit the fields on either side, and the stones gathered year by year from these fields are thrown into the road, which gradually becomes elevated above the fields. These broken fragments, worn smooth by travel, are as unable to give foothold as is the shingle of a beach, and the horse's feet sink deep at every step, making progress slow and uncomfortable. In about four hard hours after leaving Jebail, Hâkel is reached. M. Botta says of it: "Ce lieu est dans une vallée profonde située à une grande hauteur au-dessus de la mer car il faut monter pendant six heures pour y arriver et les nuages la parcourent." This is hardly correct, though quoted by M. Alois Humbert without comment; for, after the first ascent behind Jebail, the road keeps a general level, sometimes rising and sometimes falling, but never rising much higher than the points at the back of Jebail, some of which are constantly in sight, and, finally, a considerable descent is made just before reaching Hâkel. I had no instrument with me for determining the height accurately, but took, as a landmark, a well-known convent near the sea, which was always in sight until Hâkel was nearly reached, and whose height is about 600 feet above the sea. Near Hâkel, with the convent and Hâkel both in sight, I estimated the height of the latter place at 800 or 1000 feet only, and its distance from the sea in a straight line at about six miles. I passed Hâkel, and followed the valley nearly a mile, until the sides of the ravine nearly closed together, and to where the valley itself was choked by masses of fallen rock, and there, below the celebrated fish quarries, pitched my tent, Tuesday, September 18th, 1877, and remained there until the 28th. Circumstances were unexpectedly favourable for me, and I collected a large and valuable lot of most superb specimens, many of them entirely new species, and some of them increasing very materially our knowledge of the relation of this place to the Sahel Alma locality. I was enabled also to obtain a more correct idea of the place, and a few most interesting facts respecting the origin of the valley and the cause of the present position of the strata in which the fish are found.

I have said that M. Humbert is the only one who has visited and described the place; and his description, though brief, is correct. Just before reaching Hâkel we round a hill and descend its side rather abruptly, until the village is reached in the bottom of a deep and narrow ravine with precipitous sides. The regular road then crosses a little bridge, and bending west again begins to ascend the steep hill-side opposite; but we, who are in search of the fish locality, do not cross the bridge. We pass through the village on the right of a little stream, which in winter is a torrent, and follow the valley towards its head. The valley enlarges a little now, and allows of the cultivation of a few small fig and mulberry orchards. We cross the stream, and go up the valley a distance of nearly a mile, when the sides of the valley again draw near together, and the valley itself becomes choked by large masses of rock which have fallen down from the precipitous sides. On our left as we ascend, the strata are regularly superposed, and the water has exposed a fine section to view; but on the right the character of the hill-side has changed, and it seems a confused mass of *débris*. Passing through the fallen masses which choke the valley where our tent is pitched, we cross the stream again to the right of the valley going up, begin to ascend diagonally, and find ourselves clambering over steeply inclined strata. The valley becomes here a large amphitheatre, narrowed below and above, and widening in the middle; it, at the same time, makes an abrupt turn to the left, and assumes a direction nearly N.E. and S.W. On the right (still going up the valley) the strata far above our heads correspond to those on the opposite side, but where we are standing, the strata are so much inclined that it is difficult to walk upon them, and this inclination extends from high up the hill-side down to the valley. The broken fragments upon the surface begin to exhibit their contents, and weather-worn specimens of *Clupea brevissima*, Blain.; *Clupea Bottæ*, Pict. et Humb.; with an occasional fragment of *Eurypholis Boissieri*, Pict., become more and more common, until, at a distance of ten minutes' walk from where we left the little stream, we reach the field of operation. All around are the evidences that collectors have preceded us. If, now, we examine our surroundings carefully, we begin to understand the situation. The valley is one of erosion. On the northern side opposite us, the superposed strata show the action of water, and reveal the different levels of the old river-bed. A hard resisting stratum projects at various heights, with a more easily disintegrated stratum or series of strata beneath, which have been washed away to quite a depth in the hill-side. The same action of water has taken place below where we are standing, and undermined the whole area, and the fish-bearing strata have fallen down and rest where they now are, a broken precipitous mass of *débris*. This fact, so far as I know, has never been alluded to. M. Humbert speaks of the fact of the steep inclination of the strata, and says that this inclination has occasioned landslips, and rendered stratigraphical observation difficult, but he does not seem to suggest that the "steep inclination" was occasioned by undermining and a consequent landfall. I have not much doubt in my own mind that such is the fact.

Sahel Alma is nearer Beirût, and may be visited from the latter place in one day, with an allowance of two or three hours at the locality. We leave Beirût early, pass by the traditional site of St.

George's encounter with the Dragon, canter over the sandy beach of St. George's Bay, and stumble on the remains of an old Roman road which cut through a cave, leaving exposed to this day a breccia of bone, flint flakes, etc. In specimens of this, submitted to Dr. Fraas, he has recognized *Bos priscus*, superior and inferior molar, *Rhinoceros tichorhinus*, inferior molar. We pass around the Dog River Promontory under the celebrated stone-cut inscriptions, ford Dog River, cross the next point, and reach Juneh Bay in an easy three hours from Beirût. About two-thirds the distance across the beach of this bay we strike up the steep hill-side toward the apparently vertical strata before us in the mountain. A short climb brings us to the convent, under the very walls of which, and in a fig orchard, outcrops the stratum of white chalky limestone whence so many beautiful specimens have been obtained. The place is about 300 feet above the level of the sea, and a little more than a mile distant from the shore. The exposed stratum is steeply inclined, as are all the strata in that part, and the exposed rock abounds in specimens, which lie in all directions, some of the fish passing through an inch or more of thickness, *i.e.* the head deeper in the rock than the tail, or *vice versa*. The rock is soft chalky white, easily cut or sawed, and differs entirely from the Hâkel rock, which is heavy, and brittle, with a much more distinct tendency to split into layers than the Sahel Alma limestone.

But I have already exceeded the limits which I intended to assign to this introductory article. The lithological and geological questions which must be answered, the relation of the fauna of the two principal localities, and the description of new and interesting species, must be left to future articles.

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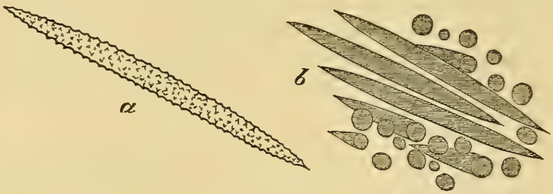
## VII.—On the Occurrence of a Freshwater Sponge in the Purbeck Limestone.

By John T. Young, F.G.S.

In the course of a re-investigation into the vexed question of the origin and nature of Chalk flints, the very natural suggestion occurred to me that the remains of a freshwater sponge might probably be found in the "flints"[1] of the Purbeck limestones, and a recent visit to Lulworth afforded the opportunity of verifying the conjecture. Patches of spicules with valves of *Cypris*, etc., etc., occur in most of the specimens then obtained. The spicules are fusiform, slightly curved and tuberculated like those of *Spongilla fluviatilis*, but larger. The longest spicule I have been able to measure is about $\frac{1}{60}$ of an inch in length; largest diameter $\frac{1}{750}$ of an inch. The spicules of *S. fluviatilis* from Henley-on-Thames average from $\frac{1}{107}$ to $\frac{1}{100}$ inch in length, and are about $\frac{1}{1500}$ inch in diameter. The sketch Fig. *b* represents a small portion of a section of "flint" (from Stare Cove) as seen by reflected light under a 2-inch objective. It has been touched with fluoric acid to bring out the spicules. Before this was done, they were so obscure as to be scarcely visible, although they are shown plainly enough on the weathered surface. The specimen from which the section was cut is almost entirely

[1] Or more properly "chert."

made up of spicules. Fig. *a* is a spicule of *S. fluviatilis* as seen under a ½-inch objective. I do not wish it to be inferred that the tuberculation of the fossil spicules is as plainly shown—it is shown, and that is all.




I do not know that the occurrence of a fossil freshwater sponge in the British area has been recorded before—and I thought it might be interesting to make a note of it now. I have no doubt a careful search would be repaid by the discovery of specimens in which the orderly arrangement of the spicules is preserved. Should I have an opportunity of doing so, some day I will look for them; if not, some one else may think it worth while to do so. Meantime, as I suppose the sponge must have a name—although I am almost afraid to suggest one, lest it should already have been noticed and named—I propose to call it *Spongilla Purbeckensis*.

## REVIEWS.

I.—The Evolution of the Tertiary Mammalia. Les Enchainements du Monde Animal dans les temps Géologiques Mammifères Tertiaires. Par Prof. Albert Gaudry. Royal 8vo. pp. 296, avec 312 gravures dans le texte. (Paris: Libraire F. Savy, 1878.)

The general tendency of modern thought among scientific men as regards the succession of animal life on the Earth has for the last twenty years flowed in an almost uninterrupted current, not always by the same channels, but biassed by the same inclination, towards the prevailing doctrine of Evolution.

Indeed, whether we turn to the East or to the West, we are forcibly struck by the cosmopolitan nature of scientific opinion in this respect. Marsh and Cope in America, Darwin, Huxley, and Parker, in England, Gaudry in France, Haeckel in Germany, Dohrn in Naples, are all directing our ideas in the same course. Even Prof. Owen, whose early researches on Homologies, like those of Linnæus in classification, were the advance-guard of the army of Evolutionary ideas, has of late adopted the legitimate consequences of the Philosophy of Evolution, by tracing the descent of some existing types of life.

These views must not, however, be classed by the reader with those chimerical speculations in which the earlier naturalists indulged, at the beginning of this century; more frequently they are the genuine outcomings of laborious research, often carried on under great difficulties, by men whose minds had been previously trained to appreciate and understand the nature of the discoveries they achieved.

Thus at Pikermi in Attica; in the far Western States of America; at Sansans, Allier, Léberon, and other localities in France, such great and important additions have been made of late to our knowledge, that it has even been found possible to speak with some confidence of the Evolution of the Mammalia since their first appearance in numerical importance in the Cainozoic period of our Earth's history.

After twenty years of research among the Tertiary Mammalia, Professor Gaudry has become convinced that the infinite diversity of forms which they manifest are the result of one dominant plan resulting from a Supreme Intelligence. This plan is made intelligible by *Evolution*, which enables him to demonstrate the relation to each other of the mammals of which remains are found in the successive Tertiary deposits. He devotes, as a rule, a chapter to each ordinal group, and begins with the Marsupials. In this notice we shall follow him through the ten chapters into which the book is divided, so as to set forth the more striking results at which the author has arrived as the reward of researches which, in this department of palæontology, have not been surpassed by any investigator.

There are no Herbivorous Marsupials in the Tertiary rocks; and it is urged that, from the way in which the movements of the parent are controlled by the helpless condition of the young, this Order would be at a disadvantage in the struggle for existence, as compared with the higher herbivorous mammals; and that this disadvantage would lead to their extermination in the European Tertiary area. In the older Tertiaries of Paris, Auvergne, and Vaucluse, Carnivorous Marsupials are found which so closely resemble the existing Opossums that at present it is not easy to separate them by generic characters.

*Hyænodon* and *Pterodon*, though in their dentition somewhat intermediate between the Placental and Implacental types, are inferred to have been Marsupials on the evidence of the form of the axis, which closely resembles that of the living American species *Didelphis cancrivora*. This intermediate character is borne out by several other genera, such as *Palæonictis*, and *Cynohyænodon* or *Proviveræa* found in the Phosphorites of Quercy. *Arctocyon* has been shown by Gervais to be an Omnivorous Marsupial, resembling the Bears. It is found impossible to understand this blending of characters in the Tertiary genera except upon the hypothesis that the Implacental mammals of the Secondary rocks became ultimately developed into the Placental type, and it is in this way that the author is disposed to explain the many resemblances to Marsupials shown in fossil Carnivora, living Lemurs and other animals.

The types of marine mammalia are not numerous. *Squalodon* in the Miocene, and the many Cetaceans of the Antwerp Crag. This evidence does not justify any conclusion as to the parentage of the Cetacea. *Halitherium* is an intermediate type between the Dugong and Lamantin; and *Pugmeodon* is intermediate between the Lamantin and *Halitherium*. *Zeuglodon* the author is inclined to place nearer to the Seals than the Whales, chiefly on the form of its skull.

The Pachyderms form a large group, and the resemblances of extinct to living species are very marked. The *Rhinoceros* was preceded by *Acerotherium*, *Palæotherium* and *Paloplotherium*; and the distinction between these types is shown chiefly in the skull and in the dentition. *Acerotherium* is essentially a *Rhinoceros* without horns, and consequently with smaller nasal bones; and the fossil species of *Rhinoceros* show all intermediate conditions of this region of the skull. The incisors of *Acerotherium* in America are three pairs, as in *Palæotherium*, and this number is also found in the *Rhinoceros Sivalensis* of India, so that there is a passage from a complete incisive dentition in this type, through various species of *Rhinoceros* to animals in which the incisors are lost. The author deals with the difficulty of molar teeth by accepting the view held by some anatomists of this country, that they are really compound teeth formed by the blending together of several simple teeth, which are now indicated by the denticles. The Tapirs are similarly traced to *Lophiodon* of the Eocene, by means of the American genus *Hyrachyus*; and the relation of the teeth of *Lophiodon* to those of *Rhinoceros* is fully indicated. The Pigs are traced in the genus *Sus* to the Middle Miocene. *Sus Lockarti* is nearly allied to *Hyotherium*, and this genus is closely allied to *Palæochærus*, which resembles the Peccary of South America. *Palæochærus* passes to *Chæropotamus*, and this genus is closely related to *Dichobune*.

The Ruminants are discussed chiefly as to their horns and teeth, and the modifications of the extremities. Unlike the Pachyderms, which abound chiefly in the older Tertiaries, the Ruminants flourish most in the later periods. The earliest known genera are *Xiphodon*, *Dichodon*, and *Amphimeryx*. Most of the older American Ruminants, like *Xiphodon*, possess some of the characters of Pachyderms. In France *Gelocus* and *Dremotherium* exemplify this point. In the Upper Miocene all the chief ruminant types are developed. The older forms, such as *Oreodon*, are without horns. The first Antelopes have the horns very small, and they appear to have developed gradually, becoming relatively large in *Antelope recticornis* of the Lower Pliocene. Antlers also developed gradually, just as they grow in complexity in the life of existing Deer. In the Middle Miocene the genus *Dicroceras* has antlers with two prongs, in the Upper Miocene the antler has three prongs, and it is only in the Pliocene and Post-Tertiary that antlers attain the complexity seen in existing species. Since the fossil antlers are always attached to the skull, the author suggests that they may have been permanent in the older types, and subsequently became deciduous, and remarks that at first only the upper portion of the antler was shed, long pedestals remaining attached to the frontal bones.

The earlier Ruminants, *Oreodon*, *Dichodon*, and *Xiphodon*, have canines and incisors in the upper jaw like Pachyderms. An elaborate examination of the molar teeth, however, fails to suggest any definite generic type of Pachyderm from which the Ruminants were evolved, though the evidence of such evolution may be regarded as conclusive. In the digits of the limbs, the author makes a point of reminding us that existing genera show transitions from types with four metapodial bones to those in which there is but one. And by tracing the ancestral forms of the more specialized living genera, a similar series of modifications is met with, until, in the earlier genera, the metapodial bones are all separated. The means by which the surviving types have been evolved are (1) the first, second and fifth metatarsals and first cuneiform are carried backward; (2) the posterior part of the third metatarsal is enlarged to sustain the cuneiform; (3) the first and second cuneiform elements of the tarsus, the second and fifth metatarsals and the trapezius become very small; (4) the bones are modified by blending of the various elements of the metacarpus and metatarsus.

The ancestry of the Horse occupies the fifth chapter, and is examined first by tracing the modifications of the teeth in Miocene and Eocene genera, and afterwards by a study of the limbs in those animals. There is but little here added to the researches of Professor Huxley, and no departure is made from the conclusions of Professor Marsh. In Europe the Horse is traced from *Paloplotherium* by way of *Pachynolyphus* to *Anchitherium*, which is allied by its teeth to *Palæotherium*, though its limbs approximate to *Paloplotherium* and *Hipparion*, which last is little more than a Horse with two small supplemental digits, one on each side of the hoof which supports the limb. This latter transition is the more interesting, since monstrosities of the living horse sometimes appear, in which the digits on one limb are developed exactly as in the Miocene *Hipparion*. Such a horse as *Equus Stenonis* of the Pliocene, in which the teeth closely approximate to *Hipparion*, is regarded as the immediate ancestor of the old-world Horse. In the extremities of the limbs *Acerotherium* of the Middle Miocene, which has three large digits and a small one on the outside, diverges considerably from the type of the living horse; but *Palæotherium*, which has three digits, of which the middle one is slightly the largest, makes a nearer approximation. In *Paloplotherium* the lateral digits and metapodial bones are much more reduced in size; while in *Hipparion* the reduction in size is carried a stage further, and the middle digits proportionately enlarged. The author quotes with approval the proposal of Professor Marsh to derive the Horse from the *Orohippus* through a series of animals which progressively increased in size; but apparently without considering that, if his own view and that of Prof. Marsh are both accepted, then we should have two distinct lines of descent for the Horse.

The sixth chapter is an exceedingly able exposition of the grounds of classification of the Ungulata by means of the teeth and limbs with a view to explaining the nature of the osteological modifications which gradually evolved the Artiodactyla and Perissodactyla from a common stock. The author considers that all the modifications which the extremities of the even and odd-hoofed Ungulata present result from the necessity that the foot should evenly support the pressure of the body. In the latter the external digit is rather more slender than the internal digit, and from this fact an explanation is derived for the circumstance that in the Perissodactyla the fibula rests directly on the tibia instead of articulating with the calcaneum, as in the Artiodactyla. This leads to the articulation of the calcaneum with the cuboid becoming smaller, and therefore to the attenuation of the fourth digit, so that the whole weight of the animal is thrown on the astragalus, which is carried by the naviculare, which is itself carried by the third cuneiform bone, which supports the third or middle digit of the foot. Hence it follows that the astragalus of the odd-hoofed types, which is flattened in front, is modified from the type of the even-hoofed animals, and the same conclusion is supported by a consideration of the other tarsal bones. It is even less difficult to establish a common parentage for the two groups by means of the teeth. These considerations raise the question whether the basis of classification should be taken from the divergent descendants which survive or have been elaborated, or whether the geological evidence has not now rendered it imperative to unite in one great group orders of animals which have hitherto been regarded as having a wider separation from each other than has here been set forth.

The seventh chapter deals with the Elephants, Mastodon and Dinotherium, all of which date from Miocene times. But slender additions are made to current knowledge of these animals, and while indicating the obvious similitudes of their teeth to those of some living types, the author finds no palæontological grounds for suggesting their parentage.

Similar difficulties, arising from the imperfect way in which their remains are known, beset the comparative study of Edentates, Rodents, Insectivora and Cheiroptera, to which the next chapter is devoted. Edentates are known in Europe, in the Eocene and Miocene; and in America they are only known from the newest formations. *Macrotherium*, an enormous animal from the Middle Miocene, might have been a climber. It had relatively small hind-limbs, and claws drawn back towards the metacarpals, so as not to impede progression on the ground. *Ancylotherium* from Pikermi is intermediate between the climbing and walking Edentates. A few Rodents occur in the Eocene; in the Upper Miocene of Greece we have Porcupines; Hares in the Pliocene of Auvergne; and Beavers in the Upper Miocene; all the extinct genera only differ from those now living in minor characters. Hedgehogs, Shrews, and Moles, are all represented in geological time; Hedgehogs in the Miocene of Auvergne; Moles in the same locality, as well as at the foot of the Pyrenees and on the Rhine; Shrews are found in the Bourbonnais; some of the old Miocene forms are so much generalized that *Plesiosorex*, for instance, was regarded as a Hedgehog by De Blainville. The Cheiroptera are very imperfectly known, and give no evidence of their descent.

The ninth chapter treats of the Carnivora. Here, especially, it is to be noted that while all the common living types have representative species in a fossil state, many date to the Pliocene period. And many of the extinct genera serve to bridge over the interval between surviving animals. Thus the Miocene genus *Amphicyon*, with a number of the most striking characteristics of Dogs, yet was a plantigrade animal like the Bears, probably able to climb, and resembled bears in minor dental characters. Again, *Hyænarctos* is between the Bears and *Amphicyon*, having an inner row of denticles to the teeth. In the same way *Cynodon* from the Phosphorites of Quercy completely bridges over the gap in dentition between the Civets and the Dogs. Hyænas, in the same manner, are shown to have been closely related to the Civets by means of the fossil genera *Ictitherium* and *Hyænictis;* the former is a modified Civet with four digits like Hyæna, and producing similar coprolites; while the latter is a modified Hyæna, closely approaching *Ictitherium*. The Martens are represented in Miocene times by European and American genera, but these do not make such striking approximations to the Civets as to altogether break down the distinction between the two groups. Some remarkable fossil genera, like *Machærodus*, have left no descendants. The author inclines to believe that carnivorous animals may perhaps be descended from the Herbivora, pointing out that Bears most nearly resemble the Pachyderms.

The last chapter deals with Lemurs and Apes. The oldest lemur is *Cænopithecus* from the Eocene, and from Quercy there are several lemurs which show affinities with the Ungulata, suggesting a common origin for lemurs and several of the Eocene pachyderms. This is also strongly indicated by the fact that Cuvier arranged the lemurine genus *Adapis* with the Pachyderms, and that Gervais provisionally classed the Lemur *Aphelotherium* near to Pachyderms.

Some of the earlier Apes also appear to have affinities with Pachyderms; this is seen in *Cebochærus* from the lignites of Débruge; and the conclusion that *Hyracotherium* presents some ape-like characters is supported by the fact that our illustrious anatomist, Prof. Owen, described, from the London Clay, some teeth as those of a monkey which he was afterwards led to refer to that genus. The teeth of *Oreopithecus*, from the Miocene of Italy, show some resemblances to *Chæropotamus*. True apes, and anthropomorphous apes, date from the Middle Miocene. The apes include *Semnopithecus* from the Sewalik Hills and Montpellier, and *Mesopithecus* from Pikermi, which appears to have been gregarious, and to have been a walker rather than a climber. This latter genus is intermediate between *Semnopithecus* and the Macaques. The anthropomorphous apes include *Pliopithecus* and *Dryopithecus*, the latter being of a very high type, but differed from Man in many points, especially in the large size of the canines in the males. Finally, a number of observers have recorded from the Miocene bones which show cuts such as might have been made by Man, and although the believers in these supposed evidences of the antiquity of our race are few, the evidence is supported by the occurrence of flint knives and other flint weapons in the Middle Miocene of Beauce. But the interval is so great between these beds and the post-glacial gravels, and the character of the human work is so like that from the more recent deposits, that some further evidence may be desired before this remote antiquity for Man is generally accepted.

In conclusion the author gives a summary, pointing out the brief duration in time of all the giant types, and gives an impartial analysis of the conclusions which we have condensed in the preceding pages. He considers that from the doctrine of Evolution we should be justified in regarding a deposit as Eocene if the mammals were numerous, but unlike those now living and unassociated with true Ruminants, Solipeds, Proboscidians and Apes. In the older Miocene we should expect to find living genera rare, Marsupials disappearing, Pachyderms passing into Horses, and the incoming of true Ruminants. In the newer Miocene Marsupials would be lost, but Ruminants, Horses, Whales, Edentates, Elephants, Carnivora, and Apes, are represented by numerous individuals and many genera, some of which diverge from living forms. While in the Pliocene the genera are mostly still living, though the species are extinct.

No popular exposition of palæontological results, so clear and profound, and intelligible to all who have a slight acquaintance with Natural History, has ever before been offered to scientific students. And the 300 excellent woodcuts carry conviction home better than words could do, and make the work invaluable for easy reference to the chief forms of fossil mammals. Points of difference with an author presenting so many striking and suggestive ideas must almost inevitably occur to readers; and for ourselves we may say that the reasons given are not altogether convincing that the even-hoofed Ungulata were the parents of the odd-hoofed section of the group, because the argument, to have been conclusive, should have been carried from the digits up to the fibula, and not from the fibula to the digits. And we venture to suggest that no cause competent to modify the relations of the fibula could be found elsewhere than in the influence of digital development and modification upon the tarsus. But although such like arguments may sometimes need a little more elaboration, no one can rise from the perusal of the book without being conscious that an invaluable survey of the Mammalia has been made by a great master of the subject, or without a feeling of gratitude to its distinguished author. H. G. Seeley.

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II.—The Lake-Dwellings of Switzerland and other Parts of Europe. By Dr. Ferdinand Keller. Translated and arranged by John Edward Lee, F.S.A., F.G.S. Second edition, greatly enlarged. In two volumes. Royal 8vo. vol. i. pp. xvi. and 696, with a frontispiece and 50 woodcuts; vol. ii. pp. 28 and 206 lithographic plates. (London: Longmans, Green, & Co., 1878.)

OWING to the great impetus given of late years to all branches of Prehistoric investigations, the publications on this subject have become so numerous that one almost needs to take advice in order to ascertain what to read, think, or avoid, on all Quaternary matters. We may, however, without hesitation, recommend to our readers such undoubtedly standard works as Prof. W. Boyd-

Dawkins' "Cave Hunting"; Dr. John Evans' "Ancient Stone Implements of Great Britain"; Messrs. Lartet and Christy's "Reliquiæ Aquitanicæ"; Sir John Lubbock's "Prehistoric Times"; Sir Charles Lyell's "Antiquity of Man"; Mr. E. B. Tylor's "Early History of Mankind"; Mr. Edward T. Stevens' "Flint Chips"; and lastly, but by no means least, Keller's "Lake-Dwellings of Switzerland and other Parts of Europe."

In August, 1877, we drew attention to this work, then in the press.[1] The first appearance of Keller's book in English was noticed by us in the GEOLOGICAL MAGAZINE for 1866 (Vol. III. p. 460). This edition formed a single volume of 426 pages and 96 plates. We now find it has grown, in 1878, to 740 pages and 206 plates, containing representations of more than two thousand five hundred objects.

Dr. Keller may congratulate himself on his good fortune in possessing such a friend and translator as Mr. John Edward Lee to make his researches known to so large a body of readers as the English language is sure to command, both here and in the Colonies, and also in the United States.

Mr. Lee's original edition of Keller's work mainly consists of a translation of his six reports presented at various times to the Antiquarian Association of Zurich, with notes and some few additions. More than ten years have elapsed since that publication appeared. In the new edition we have embodied the whole of the previous matter and a seventh report by the same excellent authority. To this Mr. Lee has added a short account of every settlement of interest which has been carefully explored, always, as far as possible, translated or abstracted from the original report or memoir. In the first edition about 1500 lake-dwellings were noticed; the present edition contains descriptions of between two and three thousand!

It is hardly too much to say that the work, as it now appears, embodies all that has hitherto been written upon this interesting subject, whether from English, French, Swiss, German, Austro-Hungarian, or Italian sources of information. Strange to say, that the Dutch, who, from the earliest times to the present day, have always been the greatest pile-dwelling and pile-driving nation in the world, find no place in these volumes. Will no enterprising native venture to write a history of the first pile-dwelling in Holland? Or is the Dutch mind too prosaic and matter-of-fact to enter upon such speculations? We hope, if Mr. Lee ventures on a third edition, he will avail himself of this suggestion.

One feature of the new edition of Keller's "Lake-Dwellings" is the introduction of much valuable information relative to the persistence among various races of mankind of the practice of erecting similar structures at the present day. If the old feudal stronghold of our ancestors, with its outworks, drawbridges, and moats, is but a modification of the still more primitive crannoge and pfahlbau: what wonder then if actual pile-dwellings should have

[1] See GEOL. MAG. 1877, Dec. II. Vol. IV. p. 366.

survived among modern savages in their original simplicity in such varied localities as the Lake-district of Central Africa; New Guinea; Venezuela; on the Gulf of Maracaibo; on the Orinoco; and the Amazons in South America? In Singapore and Japan this form of pile-dwelling over the water is still in vogue. It is the best possible proof that in the construction of these primitive habitations, as in the fabrication of his weapons, early man, under similar circumstances, and impelled by like necessities, has always acted in a similar manner independent of time and space. We do not therefore attach any special importance to the fact of the early Swiss Lake-Dwellers using this form of habitation; we believe it was a necessity of their existence which caused them so to build. Dr. Keller himself observes:—"As no national distinction can be proved between the dwellers on land and the dwellers on the lakes, so in like manner no serious doubt can arise as to the identity of the people who first made use of stone celts, then made implements of bronze of admirable quality, and, lastly, forged its weapons and tools out of iron. The difference of material used for the various implements marks the epochs which follow each other in the development of one and the same race, not the degree of civilization of different peoples." (p. 493.)

The researches of Professors Heer, Rutimeyer, and others, into the plant- and animal-remains discovered on the sites of these amphibian habitations show that even the older pile-dwellers attempted the cultivation of some cereals to be stored together with dried fruits for winter use; and although in the earliest dwellings the larger proportion of animal-remains are made up of the bones of wild beasts, such as the red deer, the wild boar, roebuck, etc., yet they seem at that period already to have possessed the cow and the goat. At first these were no doubt kept simply for the sake of their milk; but oxen were employed from a very early period to draw loads; the discovery of the pig as a source of excellent food, and probably as a substitute for cannibal repasts, belongs also to an advanced period of primitive life. From the earliest times man appears to have been accompanied by the dog, which, in his hunter state, and also afterwards as a shepherd or swineherd, would prove a most valuable companion, worthy to share in his repasts and to enjoy the warmth and shelter of his hut or cave.

The process of Evolution can clearly be traced in the relics of these early abodes of man; for with advancing civilization we find not only the diminution of wild animals eaten as food, and the obvious greater consumption of domesticated breeds of pig, ox and sheep, but his weapons increase in quality of workmanship and materials, and the horse, and probably also the ass, were added to his other domesticated animals.

One interesting geological feature connected with these early habitations in Switzerland is, that in many instances they afford valuable evidence as to the rate of the filling up of lakes by vegetable growths, and by the accumulation of sediments or alluvial deposits. From the evidence collected by Mr. Lee it would seem that of the two causes in operation, plant-growth is a more rapid agent in filling up lakes than the washing down of sediments. Or perhaps it would be more correct to say that every deep mountain lake is being slowly but surely shallowed by the yearly accumulation of sediments, and that having at last reached a moderate depth, at which aquatic plants thrive and grow most freely, the final filling up of the lake is accomplished in a comparatively brief period of time by the more rapid production of peat, and the fixing of iron.

Mr. Lee alludes (in a foot-note, on p. 495) to Mr. A. Tylor's "pluvial period," which he thinks "many of the lake-dwelling facts, *as far as they go*, seem rather to favour;" but we are not disposed attach any special or peculiar meteorological import to the growth of peat save that it proves the climate to have been humid, the temperature probably equivalent to that of Ireland, the country no doubt being everywhere clothed with forests which even spread high up the mountain sides.

If we venture to make any general remark on this new edition of Keller's Lake-Dwellings, it is in reference to the scrupulous fidelity of the translator (whether in dealing with the Reports of Dr. Keller himself, or, the thousand and one separate papers by other authors, which he has so laboriously brought together in this volume) in always adhering to the original text, when a departure from it would, we think, have been not unfrequently an improvement, and have in many instances avoided a too-frequent recurrence, in different words, of the same general ideas, which, having been once enunciated, need not be again reiterated. Whether as the faithful historian or the patient translator, we would crave none better than Dr. Keller and Mr. John Edward Lee.

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III.—Memoirs of the Geological Survey of England and Wales. The Geology of the Fenland. By Sydney B. J. Skertchly, F.G.S. 8vo. pp. 335, with a map and 23 plates. (London.)

THERE is no tract in the British Isles which could be expected to offer less temptation to the geologist than that large area, including the Bedford Level, which is known as the Fenland. Forming portions of six counties,[1] it occupies about 1300 square miles, for the most part consisting of a monotonous plain from five to twenty feet above the mean tide-level, and only diversified by slight elevations which, like islands, stand out here and there from the apparently dead-level of the fens. Much of this land, we are told, is below the high-water mark of ordinary tides, and would be overflowed almost daily, but for the erection of great banks along the sea-board.

Happily the geologist is not confined to the scenes of the present day, for however uninviting these may be, he can usually excite within himself some enthusiasm by directing his mental vision to those changes which have taken place in past times, in restoring to his mind's eye pictures of the ancient scenery, and in reading those

[1] Lincoln, Northampton, Huntingdon, Cambridge, Suffolk, and Norfolk.

lessons in the history of life which the hard facts of Geology continually reveal. Thus such a dreary district as the Fenland may become invested with considerable interest.

To attain to this happy state of mind, much hard work must first of all inevitably be done; and Mr. Skertchly, in prosecuting the work of the Geological Survey, has devoted four years to field-work and to the study of the ancient and modern historical records which treat of the land he describes.

It must not be supposed that the district has altogether been neglected by geologists, and attention is drawn to the observations especially of Sedgwick, Rose, Fisher, Bonney, and Seeley, who have made frequent excursions into the Fenland.

Their general conclusions, however, by no means harmonize with those at which Mr. Skertchly has arrived, and if they seem to be rather severely criticized, some of them, at any rate, will be able to do battle in support of their views.

Briefly to state his conclusions, we may use Mr. Skertchly's own words. He claims to have finally settled the relations of the peat and silt beds to each other, the age and marine nature of most of the gravels, the origin of the Boulder-clay, and the interglacial age of the palæolithic deposits.

Mr. Skertchly describes the Fenland as an old bay excavated in the Kimmeridge and Oxford Clays, and filled up with peat, and gravel, and silt, and Boulder-clay.

He states that the estuaries of the fen rivers are now enclosed marshes; and the Wash, whatever parts of its area may formerly have been, holds no such relation to the rivers, nor are any of the fen-beds delta-deposits.

Three areas of gravel are noted at the surface: a northern area which merges into the hill drift of Lincolnshire; a western area which is a true beach gravel; and a southern and eastern area, which seems to be the remains of the old valley gravels of the adjacent rivers. These are all older than the peat and silt beds, and are considered newer than the Chalky Boulder-clay.

The peat land occupies the western and southern portions of the Fenland; the silt land the north and central portions; and they show that the ground was a debatable one between the land and sea: for when the one prevailed, peat grew; and when the other had the mastery, silts were deposited. There is no definite order of succession in these two groups, inasmuch as they inosculate one into the other.

In the vicinity of the highlands buried forests are found in the peat, and five distinct horizons of trees are noticed.

In the valley gravels, which are known to be newer than the Chalky Boulder-clay, palæolithic implements are found; and in the newer fen strata many neolithic implements are met with.

The author discusses the break between them, and maintains that the palæolithic deposits belong to an interglacial period.

We need not follow him through his history of the Fenland in Roman, Early English, and subsequent times. He has gone over all the old records of the district and epitomized them; a study which is most important for the proper understanding of the present state of the Fenland. Notices of the chief drainage works, descriptions of the physical features, and accounts of floods and storms are given.

The questions of evaporation and drainage are discussed in some detail, and the author draws attention to and describes an instrument designed by Mr. S. H. Miller, F.R.A.S., and himself, called the Evaporimeter; the object of which is to ascertain the effects of different soils upon evaporation.

Full accounts of other meteorological matters, such as rainfall, winds, etc., are given. These and other details render the work as much a manual of the Archæology and Physical Geography of the Fenland, as of its Geology.

One chapter of especial interest to geologists is that on the Boulder-clay. This deposit skirts the Fenland, and in Mr. Skertchly's opinion underlies most of that area, and is in some places surprisingly thick.

Thus the well sunk in 1828, at Boston, pierced beds to a depth of 572 feet, the whole of which he states to be Quaternary; and of these the Boulder-clay is estimated to have a thickness of 460 feet. The shells which are mentioned at various depths belong to the genera *Gryphœa* and *Ammonites*, specimens of which have been preserved. These, he states, are all glaciated.

This is the Chalky Boulder-clay, and Mr. Skertchly argues that it is of terrestrial origin. He points out, in support of this view, that its included materials vary according to the nature of the deposit over which it is spread. At the same time Chalk is almost invariably present. If it were iceberg drift, the component materials must be those of the distant gathering grounds, and not those of the rocks they fall upon as the berg melts away. Moreover, for icebergs to carry the *débris*, we must admit a submergence of at least 500 feet, and granting this, then very little Chalk would be left above water, and no traces at all of the Oxford and Kimmeridge Clays, the wrecks of which are locally abundant in the Boulder-clay.

There is an account of the great boulder of Cretaceous rocks at Roslyn Hole, Ely, which formerly led to much discussion in the pages of this MAGAZINE, and Mr. Skertchly states that he has seen Boulder-clay underlying these transported beds.

A classification of all the beds in the Fenland, with remarks on the physical conditions which attended their deposit, is given, and the author points out that he independently came to similar conclusions concerning the Glacial and Post-Glacial events, to those arrived at by Dr. James Geikie, and published in "The Great Ice Age." He briefly adverts to his discovery of palæolithic implements in inter-glacial brick-earth beneath the chalky Boulder-clay near Brandon, a further account of which is promised in a Memoir on the Gunflint Factory. Until all the details of such an interesting discovery are made known, we must be content to suspend our judgment. Nevertheless, however startling it may seem, and however much opposed to our early teachings and convictions, so much new light has been thrown on the physical and palæontological history of the Glacial

Epoch by the writings of Dr. James Geikie and Dr. Croll, that our faith in the entirely Post-Glacial age of man requires considerable modification, and we are forced to admit that he dwelt in this country at any rate before some of the great epochs of cold which glaciated our northern counties.

Enough has been said to indicate that this volume treating of the Geology of the Fenland contains matter of more than local interest. It is well illustrated, and we can only regret that its price (forty shillings) must have a very disadvantageous influence upon its distribution.

[P.S.—Since writing the notice of Mr. Skertchly's book on the Fenland, I have had the opportunity of again visiting Brandon under his guidance, and have seen evidence which completely satisfies me that some of the beds yielding palæolithic implements are older than the Chalky Boulder-clay. I hope Mr. Skertchly will soon make public all the evidence upon which his interesting and most important discovery is founded.—H.B.W.]

## REPORTS AND PROCEEDINGS.

Geological Society of London.—I.—March 20, 1878.—Henry Clifton Sorby, Esq., F.R.S., President, in the Chair.

The following communications were read :—

1. "On the Chronological Value of the Triassic Strata of the South-western Counties." By W. A. E. Ussher, Esq., F.G.S.

The author maintained that the general thinning-out of the Trias in the South-Devon and West-Somerset area as it is traced northward, of which he adduced evidence, proves that this area was not connected with that of Gloucestershire and the midland counties until the later stages of the Keuper; and endeavoured to show by a comparison of sections that the area east of Taunton and south of the Mendips was not submerged before the deposition of the Lower Keuper Sandstone, and probably not until the later stages of its formation, the Quantocks acting as a barrier dividing the Bridgewater area from the Watchet valley. He thought that a subsidence progressing from south to north led to earlier deposition in South Devon, and to a consequent attenuation of the lower beds towards Watchet and Porlock. Hence the lowermost beds of the Trias of the south coast are much thicker than their more northerly equivalents, and probably were still thicker where the English Channel now flows, some beds perhaps dating as far back as Permian times. The presence of numerous fragments of igneous rocks (quartz-porphyries) in the basement-beds of the South Devon Trias, and the absence of known corresponding rocks in the county, led the author to infer that the cliffs and beds of the early Triassic sea were composed of such rocks, any undestroyed portions of which would probably occur either under the Triassic beds near Dartmoor and between Newton and Seaton, or in the area now occupied by the English Channel. As continuity is evident only in the upper division of the Trias, between the area of Devon and Somerset and that of the midland counties, and there is no unconformity in the former, the author maintained that the upper marls, upper sandstones, and probably the conglomerate and pebble-bed subdivision of Devon and Somerset, are equivalent in time to the Keuper series of the Midland counties, and that deposition took place in Devon and Somerset between Keuper and Bunter times, bridging over the hiatus marked by unconformity in the Midland counties.

2. "Note on an *Os articulare,* presumably that of *Iguanodon Mantelli.*" By J. W. Hulke, Esq., F.R.S., F.G.S.

In this paper the author described what he believed to be the *Os articulare* of *Iguanodon Mantelli*, from the best specimen of a series of five collected by the Rev. W. Fox, of Brixton, in the Isle of Wight. He remarked that the mandible represented by this bone differs greatly from that of the Crocodilia, and, in a less degree, from that of extant Lizards, while in some respects it resembles that of *Hypsilophodon Foxii.* From this resemblance and the relative abundance of the bone in the same beds which have yielded mandibular rami of *Iguanodon,* he felt justified in referring the bone to the latter Saurian.

3. "Description of a new Fish from the Lower Chalk of Dover." By E. Tulley Newton, Esq., F.G.S.

The author referred to his previous descriptions of fishes from British Cretaceous rocks belonging to Prof. Cope's genera *Portheus* and *Ichthyodectes*, and stated that he had since obtained a form referable to the allied genus *Daptinus.* The specimen is in the collection of the British Museum, and was procured from the Grey Chalk of Dover by Mr. Gardner. It consists of the head and some vertebræ, the characters of which are described in detail by the author, who stated that in some characters, especially the degree of flattening of the teeth, the fish seems to stand between *Ichthyodectes* and *Daptinus*, and hence proposed to name it *Daptinus intermedius.* The author further noticed the existence in the British Museum of a right maxillary bone from the Lower Chalk of Dover, which he thinks may indicate a second species of the same genus.

4. "Further Remarks on adherent Carboniferous Productidæ." By R. Etheridge, jun., Esq., F.G.S.

The author stated that since his former paper on this subject (Q.J.G.S. vol. xxxii. p. 454), his *Productus complectens* had been found in various localities, as in Northumberland, in Fifeshire, and near Dalry, in Ayrshire. The last mentioned may be a distinct species. He further described two specimens of adherent Productidæ, one from Scremerston quarry, Northumberland (near Berwick), and one from Kinghorn, in Fifeshire, the characters presented by which led him to refer them to the genus *Chonetes.*

5. "The Submarine Forest at the Alt Mouth." By T. Mellard Reade, Esq., F.G.S.

The right of the remains of trees on the shore at Great Crosby, in Lancashire, to be regarded as representing a submerged forest having been called in question, the author desired to place on record the results of an investigation which, he thought, would dispose of all doubts on the subject. On cutting a trench through 1 foot of peat and 14 inches of clay round one of the stumps, which had an oak trunk lying by it, apparently in the position in which it had fallen, the observers saw that roots were cut through all round, running along near the surface of the clay, or penetrating it diagonally; while rootlets and tap roots descended vertically into the clay. Several of the main roots were traced for a considerable distance into the clay. On raising the stump out of the ground, the clay showed numerous root-sections. The examination of the stumps gave confirmatory results.

II.—April 3, 1878.—Henry Clifton Sorby, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "On an Unconformable Break at the base of the Cambrian Rocks near Llanberis." By George Maw, Esq., F.L.S., F.G.S.

In a paper read before the Society on December 5, 1877 (Q.J.G.S. vol. xxxiv. p. 137), Prof. Hughes referred to an observation made by the author in 1867 as to the occurrence near Llanberis of an unconformable break, indicating the base of the Cambrian; and, while accepting the asserted existence of pre-Cambrian rocks in North Wales, placed the base of the Cambrian in a very different position, and maintained that the appearances described by Mr. Maw might be accounted for by lateral pressure acting upon beds of dissimilar texture and unequal hardness. The author had re-examined the section in question, and maintained his original interpretation of the phenomena, which he regarded as the earliest indication of the existence of a pre-Cambrian series. He accounted for differences observed in the supposed pre-Cambrian rocks at Moel Tryfaen and Llanberis by regarding them as having undergone different degrees of metamorphism.

2. "On the so-called Greenstones of Central and Eastern Cornwall." By J. Arthur Phillips, Esq., F.G.S.

In this paper the author extended his investigations of the rocks formerly mapped as greenstones, from the western (see Q. J. G. S. vol. xxxii. p. 155) into the central and eastern districts of Cornwall. He described in detail various rocks from different parts of these districts, the examination of which had led him to the following conclusions. The numerous lavas which occur here, in addition to the rocks met with in Western Cornwall, are so interbedded with the slates and schists as to lead to the conviction that they are contemporaneous, and, although much altered, they closely resemble lavas of more modern date. Sometimes they assume a distinctly schistose character. The crystalline greenstones are more varied and instructive than those of the western portion of the county; some of them are typical dolerites, while others are so altered as to consist only of a granular indefinite base, traversed by indistinct microlitic bodies. Their pyroxenic constituent is augite; and, although many would call them diabases or melaphyres, the author regards it as more logical to regard them as ancient dolerites. Where these rocks are altered, the augite is usually changed into hornblende and viridite, while the felspar becomes cloudy, and finally merges into a granular base. The crystals of augite are often gradually replaced by an assemblage of felted microlites; in other cases their outlines are preserved, whilst their substance is replaced by hornblende, the rock being thus converted into a *uralite dolerite* or *uralite diabase.* When these rocks do not contain augite, and are to a great extent composed of long bacillary hornblendic crystals made up of parallel belonites, the ends of which are frequently curved outwards, it is probable that hornblende was an original constituent of the rock, which is therefore a true diorite. Slaty or schistose greenstones are less frequent than in the western districts, but on St. Cleer Down the "hornblende-slates" graduate imperceptibly from crystalline dolerites into clay slate; these are not improbably of igneous origin. Some of the slaty blue elvans are identical in chemical composition with the dolerites, and may be highly metamorphosed ash-beds, although, from some of their characters, it seems more probable that they are true igneous rocks. The felspar in the brecciated slates is almost entirely plagioclase. and is derived from the disintegration of greenstones. With regard to the age of the rocks described, the author states that they are generally older than the granite; for the vesicular lavas and many slaty hornblendic bands are evidently contemporaneous with the slates among which they are bedded, while the latter are often displaced by the granite or traversed by granitic veins; and, further, the eruptive doleritic rocks which break through the sedimentary beds never traverse the granite, but are often interrupted by it.

3. "The Recession of the Falls of St. Anthony." By N. H. Winchell, Esq. Communicated by J. Geikie, Esq., F.R.S., F.G.S.

The author's purpose in this paper was to arrive at an estimate of the date of the last glacial period from the rate of recession of the Falls of St. Anthony, near the junction of the Minnesota and Mississippi rivers. He stated that the country is covered with deposits of glacial origin, that between the present falls and Fort Snelling, a distance of eight miles, the existing river-gorge has been formed since the deposition of the newer Boulder-clay, and that the old river-valley is filled up with glacial deposits. The gorge is of very uniform character, being cut through hard limestones resting on soft sand rock, both lying quite horizontally. The country was settled in 1856, and the recession of the falls has since been very rapid, its rate having been accelerated by the erection of saw-mills, dams, etc. From the accounts of various travellers who have visited the falls in the last 200 years, the author endeavoured to obtain an estimate of the true rate of recession. Between the visit of Father Hennepin in 1688 and that of Carver in 1766 he finds a recession at the rate of 3·49 feet annually; between Carver's visit and 1856 a mean annual recession of 6·73 feet; and between Hennepin and 1856 one of 5·15 feet. The time-estimates for the cutting of the gorge would be, according to the above means, 12, 103, 6, 276 and 8, 202 years. The author considers the data upon which the second of these numbers is founded the most reliable.

# CORRESPONDENCE.

## ON TERMINAL CURVATURE IN THE SOUTH-WESTERN COUNTIES.

SIR,—Notwithstanding its ten years' rest, this subject seems to retain its marrow as a bone of contention, judging from Mr. Mackintosh's letter in your last Number. Mr. Mackintosh seems to have mistaken the object of my paper, as I had of his; for had I known that "none" of the solutions proposed by him were "confidently advocated," by making the real object of my paper more prominent, and dwelling less upon his hypotheses, I might have appeared less controversial. The principal object of my paper was to deprecate the invocation of glacial action in explanation of phenomena otherwise more reasonably explainable, and especially so in districts where all direct proof of glaciation is wanting.

The keynote of my objection to all Mr. Mackintosh's explanations is struck in his declared scepticism in a "great surface waste and contour moulding" of the South-western Counties during Pleistocene times. How any geologist can calmly contemplate the distant table-land of the Blackdowns from its insulated remnant Haldon, and gazing across the broad valley of the Exe, excavated entirely since the accumulation of the clay with flints, deny the vast contour moulding and surface waste of Pleistocene ages, it is difficult to conceive. I can only regard the hypotheses alluded to by Mr. Mackintosh as untenable as regards the "Head" of Devon and Cornwall, having a very wide acquaintance of the facts, and feel that I must hide my diminished "Head" under some more congenial covering than an Arctic Sea or "immense ice-water lake." My idea of a greater elevation of land, accompanied by a more rigid expression of the present causes of subaerial waste, not only suffices to explain the formation of "Head" proper (*i.e.* the angular accumulation of stony loam intermediate in time between the elevation of the beaches and the submergence of the forests), but also fits into a necessary sequence of physical changes.

I do not believe in uniformity of direction of curved-back laminæ, such directions being dependent on dip and strike of cleavage planes. The effect of roots in wedging off laminæ is very local, seldom causing reversals extending more than a few feet from them. I must, in conclusion, apologize to Mr. Mackintosh for having misunderstood him about the direction of the cleavage planes on the northern slopes of Brendon Hill; my objection to ice-passage on the ground of the absence of terminal curvature, consistently with his theory, on the north slope, was based on the assumption that the laminæ inclined in a southerly direction at a high angle, but not approximating to the vertical. Any apparent controversial spleen in the foregoing remarks must be attributed to that pardonable partiality for their own specialities generally exhibited by local geologists, and to no unfriendly spirit as regards Mr. Mackintosh.

W. A. E. USSHER.

## TERMINAL CURVATURE IN WEST SOMERSET.

Sir,—The accompanying short extract from Sir H. de la Beche's "Geological Observer," p. 23, 2nd edit. 1853, contains remarks so apposite on this subject, that I trust Mr. Mackintosh will allow me to call his attention to them, if he should happen not already to be familiar with them.

"The rain-waters not absorbed by the rocks, act mechanically on the surface of the land, removing to lower levels such decomposed portions of the rocks as their volume and velocity can transport. The mixed effects of decomposition from atmospheric causes, and of soaking of the surface on hill-sides, are often well shown in slate countries, a certain depth beneath the soil exhibiting the turning over of the edges of the slates towards the valleys;—as it were the tendency of the moistened matter of the surface to slide by its gravity to the lower ground.

"The accompanying figure" (showing highly inclined strata with the upper portion beneath the soil bent over into a curvature 'against their nap') "will illustrate this fact, one of much importance to the observer, for without attention to it he might commit grave errors as to the true dip of the strata, when only a slight depth of section may be exposed on the hill-side. In the above figure the real dip of beds is represented as the very reverse of that which might be inferred from a hasty glance at the surface. Although it may be supposed that the difference between this sliding down of the surface towards the lower grounds and the true dip was always so apparent as not to be mistaken, the depth to which this action has occasionally extended is sufficient to justify great caution in many districts."

It is to be remembered that ground that is now level may, at the time when this curvature was produced, have been inclined towards then-existing valleys. H. E. H.

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## THE GORRAN BEDS AND BUDLEIGH SALTERTON PEBBLES.

Sir,—I observe that in the discussion, on the 20th March, 1878, on Mr. Ussher's paper on "The Chronological Value of the Triassic Strata of the South-western Counties," as reported in the "Abstract of the Proceedings of the Geological Society of London, No. 350," "Mr. Etheridge said that he had been able to ascertain from specimens in the Penzance Museum that the Budleigh Salterton Pebbles came from Gorran [printed incorrectly Gowan] on the southern coast of Cornwall," and that "Mr. Whitaker stated that he had himself, on lithological grounds, suggested the Gorran Haven region as a source for the Budleigh Salterton pebbles."

These statements interest me a good deal, since they are confirmatory of those contained in the following quotation from a paper which I had the pleasure of reading to the Plymouth Institution as long ago as 30th March 1865:—"Having learned that Mr. Peach had lodged in the Penzance and Truro Museums such of the fossils [from near Gorran] as he had collected, Mr. Vicary, Dr. Scott, and I went into Cornwall early in July last (1864), for the purpose of examining them and the rocks in which they were found. The fossils are in many cases so fragmentary or indistinct that identification is by no means easy; nevertheless, we succeeded in detecting among them several specimens of one of the Budleigh Salterton species of *Brachiopoda.* Having been furnished by Mr. Peach with all needful information, we were so fortunate as to secure the assistance of one of his old collectors, who conducted us to the fossiliferous beds of the Great Cairn and Great Peraver, near Gorran Haven. In the Peraver, we succeeded in finding fossils having the same general facies as those of the "pebble-bed," and inhumed in quartzites identical in structure and even in hue with the pebbles of South-eastern Devonshire." (See Transactions Plymouth Institution, 1864–5, vol. i. pp. 22–3.)

TORQUAY, *4th April*, 1878. WM. PENGELLY.

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ON THE ORIGIN OF A QUARTZITE BOULDER FROM THE BUNTER CONGLOMERATE, NOTTINGHAM.

SIR,—A short time ago it was my good fortune to find, in a heap of road-metal, near Nottingham, a liver-coloured quartzite boulder, no doubt derived from the Bunter Conglomerate of the district, which exhibits on its fractured surface a well-defined concave cast of *Orthis redux*—a Caradoc fossil that is, I understand, by far the most frequent species in the quartzite pebbles of the Triassic shingle beds of Budleigh Salterton, Devon, and of similar deposits in the North of France.

In recording the occurrence of the above fossil in this locality, I am content to leave the question whence this and similar pebbles in our Bunter Conglomerate were derived for the consideration of those who are more competent than myself to offer an opinion on the subject.

NOTTINGHAM, *March 18th*, 1878. J. H. JENNINGS.

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## OBITUARY.

### JOHN ROFE, C.E., F.G.S., ETC.

BORN, 14 OCTOBER, 1801. DIED, 11 APRIL, 1878.

We regret to record the loss by death of an excellent geologist, a much valued friend, and a frequent contributor to this Journal.

Mr. Rofe was born in London, Oct. 14, 1801, and was educated at Enfield, by the late Mr. Cowden Clarke, and afterwards at Reading with the Rev. Dr. Williams.

He studied engineering under his father Mr. John Rofe, C.E.; and afterwards, in partnership with him, carried out many important public works, notably the Birmingham Gas, and Water-Works; the Reading Gas-Works; Gas and Water Engineering Works were also carried out by Mr. Rofe for the towns of Leicester, Guildford, and Boston. On several occasions he gave valuable evidence in Committee before the House of Commons, with reference to public Towns Water Works and Gas Companies Bills, in which his sound geological knowledge proved of great service to him.

On the 26th June, 1827, he married the daughter of the Rev. Bartholomew Goe, Vicar of Boston, Lincolnshire, and settled in

Preston as Engineer to the Gas Works, a post which he held for twenty-five years.

While resident in Preston he took a very active part in the Literary and Philosophical Society of that town, and in December, 1845, a service of plate was presented to Mr. Rofe by the members "in acknowledgment of the zeal and ability with which he had promoted the establishment, progress, and success of that Institution."

He had only one son and daughter; the latter married Dr. Fearnside of Preston; the former (the Rev. John Rofe), a young man of high promise, after graduating at Cambridge, 1850, received in 1859 from the Master of his College (St. John's), the offer of an Indian Chaplaincy, which he accepted. He officiated as Chaplain to Lord Canning (then Governor General of India) during a tour in the North-West Provinces; and finally as Chaplain to Dr. Cotton, Bishop of Calcutta—with whom, whilst on a visitation tour, he died in 1861, at the early age of 34 years.

This severe family bereavement had no doubt a most depressing influence on so amiable a man as Mr. Rofe, and caused him to spend much of his time in the retirement of his library or engrossed in the study of his fine private collection of Crinoidea from the Carboniferous Limestone of Clitheroe. Having resigned his official duties at Preston from ill-health, he devoted himself to a careful study of the internal anatomy of the fossil Echinodermata, and his valuable researches will be found embodied in a series of papers printed in this MAGAZINE, a list of which is subjoined.

For some years he resided at 15, Abbey Place, St. John's Wood; but afterwards removed to Lancaster, where he was elected President of the Lunesdale Naturalists' Field-club; his health, however, did not long permit him to retain the office. For the last few years he has resided at Leamington, but of late he has been prevented by failing eyesight from carrying on his favourite microscopic researches. In February last he presented his rich collection of Crinoidea and other fossils from the Carboniferous Limestone (numbering upwards of 1,500 specimens) to the National Museum.

He died at his residence, 9, Church Hill, Leamington, on the 11th day of April, at the age of 77 years.

The following are the titles of Mr. Rofe's scientific papers:—


1. "Observations on the Geological Structure of the Neighbourhood of Reading" (read Feb. 26, 1834), Trans. Geol. Soc. 2nd series, vol. v. 1840, p. 127. Proc. vol. ii. p. 72.
2. "Description of a New Species of *Actinocrinus* from the Mountain-Limestone of Lancashire" (with 3 woodcuts), GEOL. MAG. 1865, Vol. II. p. 12.
3. "Notes on some Echinodermata from the Mountain-Limestone," etc. (with a plate), GEOL. MAG. 1865, Vol. II. p. 245.
4. "Notes on Coal and Cannel," GEOL. MAG. 1866, Vol. III. p. 208.
5. "Note on the late Colliery Explosions," GEOL. MAG. 1867, Vol. IV. p. 106.
6. "Note on the Cause and Nature of the Enlargement of some Crinoidal Columns" (with 5 woodcuts), GEOL. MAG. 1869, Vol. VI. p. 351.
7. "On some supposed Lithodomous Perforations in Limestone Rock" (with a plate), GEOL. MAG. 1870, Vol. VII. p. 4.
8. "Notes on the Crinoidea" (with a plate), GEOL. MAG. 1871, Vol. VIII. p. 241.
9. "Further Notes on the Crinoidea" (with a plate), GEOL. MAG. 1873, Vol. X. p. 262.
10. Presidential Address to the Members of the Lunesdale Naturalists' Field-club, 25th Feb. 1873: "On the Geology of the District around Lancaster."—H.W.

THE

# GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. V.

**No. VI.—JUNE, 1878.**

## ORIGINAL ARTICLES.

### I.—Physiography.

By C. Lloyd Morgan, F.G.S., A.R.S.M.

THE artist who is illustrating a great theme upon a large spread of canvas finds it necessary from time to time to lay down the brush, with which he is accurately filling in the more delicate minutiæ, that he may retreat to a distance and view his picture as a whole. It is essential to the higher development of his art that he should not omit this comprehensive survey. The same thing holds good in Literature and Science, as well as in Art. The historian must, from time to time, take a fresh survey of History as a whole. If he neglect to do so, the group of figures to which he devotes his special attention will certainly not take up its true position among the other groups that appear on the canvas of History. The man of science, also, should not forget that he is, according to his individual bent or capacity, aiding in the construction of a great Philosophy; and he should now and again turn aside from the microscope, or lay down the hammer, to take a more comprehensive survey of that Philosophy, whose aim it is to comprehend and consolidate the widest generalizations of Science.

A rude attempt at such a survey of the principles of geology and the bordering branches of science will be found in the following pages. They are from the notes of a lecture which formed the last of a course delivered before a school audience. In that lecture I did my best to give a rough sketch of that chain of events by the study of which we may build up a history of the Earth, while I endeavoured at the same time to lead my hearers upwards from the simple to the complex: for I hold that the teacher of science should lead his pupils from the well known, through the less known, to the unknown. Taking a few simple and obvious facts as a basis, he should first test whether those whom he teaches really know them to be facts, and then, carefully building upwards, seeing that each stone of his superstructure rests securely on one which has before been firmly laid down in its true place, he should mount slowly and surely, until, at last, he reaches that rare atmosphere of the unknown in which, for the present at least, no man may build.

Standing by the sea-side, then, let us inquire of Nature concerning the things which we see around us. The waves roll in upon the shore, the wind blows freshly in our faces, a heavy storm-cloud hangs over the distant horizon, at our feet is a little streamlet running over the sands to the sea; behind us is the white chalk cliff, capped with sand and clay.

How come these waves, and what are they doing? shall be our first question. The answer to the first part of the question is so obvious that a child will not hesitate to reply, that it is the wind which produces the waves. At first a mere cat's paw on the surface of the sea, the growing ripples are, as the wind continues, hurried onwards, increasing both in length and breadth, and, where the water is deep, in velocity of motion, until they become the great waves, some 14 feet high from trough to crest, which we see on our coasts during a storm, and finally, if they have a fair field, develope into ocean billows, 26 feet high in the Atlantic, 40 feet high in the Southern Ocean. In the open sea the water is not carried forward by this wave motion. We may watch the sea-bird rise and fall as the wave passes under her. She is not carried forward on its summit. But when the wave reaches shoal-water, in the neighbourhood of land, the lower part is retarded by friction against the bottom, while the upper part hurries on, and the wave breaks, and rushes up the shore, the under water racing back and tearing up the beach in its backward course. It is in this way that the sea has such power in grinding down the rocky materials which fall to the base of our island cliffs. Along the Chesil Beach the pebbles are carried forward fifteen miles by the action of the waves, and as they grind over each other in their westward course, they become smaller and smaller.

Here then we obtain an answer to the second part of our question: What are the waves doing? They are beating backwards and forwards the matter which falls from the cliffs, until it is broken up and rolled into a rounded pebbly beach. But they are doing more than this. They are battering at the cliff itself, and, aided by rain, and frost, and wind, are eating away our island shores. The force with which the waves dash against the cliffs is at times enormous, having been known to reach a pressure of more than three tons on the square foot. During the hurricane which swept over Barbadoes in 1780, cannon which had long been lying sunk were washed far up on shore.

In some parts of England the sea is advancing rapidly on the land. Prof. Huxley, in his excellent little book on Physiography,[1] quotes, as an instance, the fact that Reculver church, which in the time of Henry VIII. was a mile from the sea, is now only preserved from the destructive action of the waves by a stone breakwater made by the Trinity Board. Not long ago, I walked along the coast from Herne Bay to the Reculvers. The rapidity of the waste was clear. In many places portions of the path had been carried away. Masses of grass-covered earth, lying at the foot of the vertical portion of the cliff, showed how recent had been the precipitation from above; while the clean-cut face of the cliff, and the sharp forms of the projecting ridges and pinnacles of the clay,

[1] 8vo. pp. 384, with 5 plates and 122 woodcuts (Macmillan & Co., London, 1878).

showed that since they were left in their present position, they had not suffered for long the attacks of rain and wind. Great cracks at the surface, here and there, showed that destructive action was still in progress; and when I looked at the lately fallen blocks of earth below, I felt that it was possible that the grass tufts, on which I stood, might be the next to fall amidst the ruins beneath me. But though the action of the weather was thus clear, the sea-waves, which alone permitted that action to continue, were not idle. The brown colour of the sea for some distance from the shore gave evidence of this, and while I stood upon the beach, I saw several projecting blocks of clay wasted by more than half.

In Scotland and Western England, where the rocks are hard, the advance of the sea upon the land is quite imperceptible. All the beauties of our coast scenery, our bold headlands and sweeping bays, result from this *unequal* action of the sea upon the harder and softer rocks of which our island is built up. But little observation is necessary to make it clear that, along any coast-line, the promontories are composed of hard rock, the bays of a softer material. Sea-side scenery is, therefore, a joint product of wave action and the geological structure of the coast. We must not forget, however, that it is only along its margin, where it beats upon the shore-line, that the sea is an agent of *denudation.* Throughout its great extent the ocean is the area of deposit and construction, just as the land is the area of destruction and waste. Beneath the sea the products of that waste come to rest. Strange as it sounds, the sea is the cradle of the land. Beneath the waters of the ocean are formed those layers of sediment which will some day be raised above the waters to form the framework of new continents.

From the answer to our first question, then, we learn that the waves are advancing upon the land, and thus producing our coast scenery, and that they are caused by the winds.

Let us next consider the streamlet at our feet. What is it doing, and how comes it here? That little streamlet, if we will but listen to it, can tell us much about what the great rivers of the earth are doing. Let us learn from it. In the first place, then, we see that this miniature river[1] is gradually changing its course. The main current strikes against one bank more than the other. The result is that this bank is forced to recede. Its tiny cliffs are undermined by the action of the stream, and the upper portions, now and again, topple over with a little splash into the water. Here we have in miniature that which may be seen on an enormous scale on the Mississippi and the Amazons. Large vessels may there be made to rock by the waves created by the fall of great masses of the concave bank, the river having in this way advanced upon the land hundreds of yards, and, in some cases, even, several miles, within the memory of living men.

This shows how a stream cuts its way *sideways* into the land. This is not, however, the most important part of what a river does. If we follow our stream a little way inland, we shall discover that

[1] Miniature Physical Geology, *Nature*, March 8, 1877.

it cuts its way *downwards* and cuts its way *backwards.* Both modes of action go on, as a rule, at the same time; but sometimes one, sometimes the other, is most obvious. Of the first, the Cañon of the Colorado offers an example on the grandest scale. This great ravine is about 300 miles long and, in places, *more than a mile* deep. There can be no doubt that it has been entirely cut down into the desert plateau by the action of the river. How this was effected we learn, to some extent, from the following sentence in the American report on the river, "The water of the Colorado," says the reporter, "holds in suspension a large amount of fine siliceous sand, sharp as emery, that eats away the valves" (connected with the machinery of the steamer) "as rapidly as it could be done with a file." It has probably been with the aid of this sand that the river has cut down its deep trench.

Of a river cutting its way backwards, the Niagara is the grandest example. At the Falls the water tumbles over a ledge of limestone which rests on a thickness of shales. By the action of the spray which rises from the waterfall, and partly by the power of frost, the shale is rotted away, and thus the limestone is undermined. It is in part owing to the undermining action, that visitors can proceed a little way under the falls. To do so is well worth a wetting: a whole river takes its mighty leap, and falls with a bewildering roar at your very feet, and if it be winter giant icicles hang above your head. When the "under-cutting" has gone on for a certain time, huge blocks of the limestone tumble with a crash to the base of the waterfall. In this way the Falls of Niagara are working backwards, at the rate of about one foot a year, towards Lake Erie. Only the other day it was stated in *Nature* that, on November 17, 1877, a large section of the rock towards the Canada shore fell with a tremendous crash, and that during the night a still larger area went down.

But what becomes of all the material dug out by the stream as it cuts its way sideways, or downwards, or backwards? If we watch any little rill which falls into a pool on the sea-shore, we shall soon find out. We shall see that the sand and other material which it carries are built up into a little delta, while some of the finest material is spread at large over the bottom of the pool. Large rivers carry vast quantities of mud and sand and silt (much of which is washed off the land by the rain) to the sea. Experiments of mine on the Thames at Surbiton show that in fine weather, when the river was low and fairly clear, solid matter in suspension was being carried seawards at the rate of 9767 tons per annum; while, when the river was in extreme flood, matter at the rate of 524,940 tons per annum was passing in this way down towards the sea. With the great rivers of the world of course the amounts are still more enormous. Sir Charles Lyell calculated "that if a fleet of more than 80 Indiamen, each freighted with about 1,400 tons weight of mud, were to sail down the Ganges every hour of every day and night for four months continuously, they would only transport from the higher country to the sea a mass of solid matter equal to that borne down by the Ganges in the four months of flood season." All the matter carried down in this way is built up, layer upon layer, into a vast delta deposit, or strewn over the bed of the ocean. Of such layers much of the crust of the earth, the sand and clay at the top of the cliff behind us for example, is composed.

But besides the matter carried down by rivers in suspension, a vast amount is carried down in solution. Take the Thames for example. For every grain transported mechanically, more than 20 grains are carried down chemically. Every gallon contains some 20 grains of lime salts, and about two grains of common table salt, or Chloride of Sodium. These also are carried out into the sea, in which the Chloride of Sodium, along with certain other salts, accumulates on the evaporation of the water, and thus forms the brine of the ocean, while the Carbonate of Calcium is separated by living creatures and built up into some sort of pure limestone. Of such limestones also much of the crust of the earth, the chalk of the cliff behind us for example, is composed.

We have thus seen what the streamlet is doing. It is aiding the rivers of the world to carve out valleys, and it is carrying seawards the fine mud and sand which result from its own work and that of rain, to contribute to the framework of a future continent. And how comes it here? Directly or indirectly from rainfall. Whether its source be a spring, or the collected waters from a sloping hill-side, it matters not. Without rainfall, such as is now pouring from the distant storm-cloud, the streamlet could have had no existence.

Another question therefore suggests itself: What is this rainfall doing, and how comes it here? If we walk along the shore for a little distance, we may perhaps see (if there is beneath the cliffs any clayey material containing flat stones) small pillars of earth, each capped by one of these flat stones. These are little monuments of rain action. Rain falls upon the surface and runs off towards lower levels; as it runs, however, it carries with it a little of the fine clayey material. Thus it lowers the surface. But where there is a flat stone, the surface is protected from the softening action of rain-drops, just as a house is protected by its roof. The soil beneath the stone is not carried away, and the miniature earth pillar stands out as a monument. In Switzerland there are, in several places, earth pillars 50 or 60 feet high, which have been formed in this way.

But it is not only where there are earth pillars that the rain is exercising a denuding action upon the land. If we go out into the fields on any rainy day, we may watch how the soil is literally flowing downwards to the sea. Few fields are perfectly flat, and the rain which falls upon the surface tends to drain off at the lowest possible level. But if we examine the water which is thus on its way down the field, we shall at once see that it is not clear, that it carries with it some of the soil. Much of the rain, of course, sinks into the ground. But before it does so it is nearly sure to trickle a foot or two over the surface. Even if it only runs a few inches, it must bear with it some of the soil for this distance, and there leave it. If the rainfall continue, the soil is soon carried a few inches further; and it always travels in one direction from higher to lower levels. Our field may be separated at its lower end from another by a wall, which will check the downward progress of the soil. If this be so, we shall often find that, from the accumulation of this soil, a child may look over the wall on that side of it which faces up hill, while a full-grown man may have to stand on tiptoe to gain the same advantage on the lower side. Or perhaps at the bottom of the field there may be a ditch; that ditch may communicate with a streamlet, and the streamlet fall into a river. Some of the soil of the field is thus carried by every heavy shower of rain into the ditch, and thence into the river. After a wet day we shall find that all the tiny rills, the little rivulets, the streams, and the great rivers themselves, are muddy and thick. This mud is nearly all derived from the soil of the land which lies in the river-valley. Thus the land is always flowing downwards to the sea; not a particle can get up again when once it has flowed even a few feet in its downward course: and this action is going on wherever rain falls upon the surface of the land.

But though the surface layer is, in this way, being constantly washed off the fields, the soil does not lessen in quantity. For as fast as material is carried away by the rain, so fast does the same agent, aided by weathering action, prepare fresh soil, to be treated in a similar manner. At the same time, we must remember that, though the amount of soil does not grow less, the amount of land above the waters of the ocean does diminish. Does this seem strange? A rough analogy may serve to make it clear. A man possesses a certain amount of money, most of which is in the bank, and a small amount, for immediate use, in his waistcoat pocket. As fast as his ready cash disappears, he draws a cheque on his banker, and in this way his waistcoat pocket has a more or less constant supply. Practically speaking, therefore, his ready cash does not diminish, though his balance at the bankers does not remain equally constant, but decreases day by day, at a rate which would shortly lead to bankruptcy, if he were not careful that there should be a supply equal to the demand. Now the soil is the ready cash, and the strata of England the balance at the bank. Rainfall is continually tending to diminish the amount of soil or ready cash, which is made good by a fresh supply from the bank. It is perfectly obvious, however, that the balance at the bankers must decrease, and that in the course of ages England must be entirely washed away into the sea of geological bankruptcy, unless the bank receive a fresh supply; unless, in other words, by the force of elevation, fresh land be raised, from time to time, above the waters of the ocean.

With regard to the influence of rain on the physical aspect of a country, it may be said that, viewed on a large scale and in a general way, this agent exercises a softening effect on scenery; in those areas where the strata are of a soft and easily yielding nature, the work of rain as an Earth-sculptor is to cause the land to assume a gently undulating form, and to extend in *breadth* those valleys which rivers are always tending to extend in *depth.* On those rocks, however, which are of a harder nature, rain has less absolute power, but even here it renders the scenery less rugged; less sublime perhaps, but more beautiful.

And how comes this rain? We know that it falls from the clouds. We know too that these clouds are formed when the air above is cooled so much that it can no longer hold in solution all the vapour of water which it has borne in an invisible form from afar. The rain, therefore, comes from the vapour of water existing in the wind. And how comes it to exist in the wind? It is obtained from the Atlantic Ocean. Thither then we must travel in thought and try and picture to ourselves what takes place when the visible liquid water is converted into the invisible gaseous vapour of water. Now it is quite evident that some force is overcome—some binding force which drew the particles of water closely together. This force is cohesion. It may be likened to a strong man who holds the watery particles in bondage, not indeed so severe as that of the terrible ice-king of the Arctic and Antarctic regions, for they are allowed free motion among each other, and are not locked in the solid state, but still *bondage* chaining them down to the limits of the ocean. This strong man will not loose his grip until he be conquered by a stronger than he; and on the Atlantic he meets with that stronger man whom we call heat.

Sun-heat sets free the particles of water from the bondage of cohesion, and allows them to escape into the air. But the mastery is not gained without an effort, and the value of this effort has been calculated. To emancipate nine pounds weight of water particles, an amount of energy has to be expended, equal to that of lifting a ton to the top of a precipice 2900 feet high.[1] But just as, when two wrestlers struggle together, neither can master the other without a true waste of his substance taking place, a waste that has ere long to be made good by the absorption of a certain amount of mutton or beef, so too on the Atlantic, during the struggle between cohesion and heat, a certain amount of the latter is consumed and disappears. The amount of heat so expended has also been calculated. In setting free nine pounds of water particles an amount of heat disappears sufficient to fuse 45 lbs. of cast iron.[1]

To take leave of metaphor, this amount of heat is expended in overcoming cohesion and tearing asunder the particles of water. The vapour particles thus formed, kept separate from each other by heat, are carried by the wind to our shores; there the air in which they float is cooled; the heat is now insufficient to overcome the force of cohesion, and the water particles, no longer held apart, clash together, and as they do so they generate by the shock as much heat as was expended before in tearing them asunder. All the heat which disappeared—was rendered latent or hidden—when the vapour of water was raised from the Atlantic, is set free or rendered sensible when condensation takes place. For every nine

[1] These are two different ways of stating the *same* fact.

pounds weight of cloud formed in our skies, an amount of heat is set free sufficient to melt 45 lbs. of cast iron.

A valuable lesson may be learnt from this behaviour of water and water vapour. When the liquid water became gaseous vapour, a certain amount of heat energy disappeared. But it was not destroyed. It was converted into another form of energy which we may call the energy of separation. The particles were forcibly *separated* from one another, and a certain amount of energy was necessary to keep them apart. Presently, however, they clashed together again, and the energy of separation was reconverted into the energy of heat. The amount of heat given out was exactly equal to the amount of sun-heat absorbed. Day by day fresh experiment and observation make clearer this great law of nature: that by no means at our disposal can we either destroy or create energy. We may change it in a number of ways. We may convert chemical separation into electricity, this into mechanical motion, and mechanical motion into heat. But we can neither call into existence or put out of existence any portion of the energy of the universe, any more than we can call into existence or put out of existence any portion of the matter of the universe.

One more fact must be noticed. Though the same amount of heat is given out by the condensation of the aqueous vapour, as was absorbed on the Atlantic during its formation, it is no longer useful in the same way. It does not possess the power of again converting water into water vapour. It has become degraded. It is the same in amount, but different in value. The water which turns a mill is the same in amount, whether it lies above or below the water-wheel; but it differs vastly in value. That above the mill is useful to the miller: that below the mill is useless. It is the same with energy. Just as water tends to run down from higher to lower levels, so does energy tend to run down from higher to lower forms. All forms of energy tend to be degraded to heat uniformly diffused throughout space.

To the energy of sun-heat, then, we owe the existence of vapour of water in the wind. And to what do we owe the wind itself? To the same cause. On any winter's evening, the colder the better, we may make the following experiment, first performed by Franklin. When the dining-room is warm, but the hall outside cold, we may throw open the door to its full extent. On holding a lighted candle in the doorway near the top, we shall find that the flame is blown outwards: on holding it near the bottom, we shall find that it is blown inwards: midway between the top and the floor, the flame will burn steadily. The cause of this is obvious when we remember that warm air is lighter than cold air. When the door is opened, warm air rushes out near the top, and, to supply its place, cold air rushes inwards along the floor. The two currents are divided by a calm.

At the seaside we may watch the same sort of experiment performed on a larger scale by nature. In settled summer weather sailors count on a sea-breeze in the morning, and a breeze from the land at night. The cause of these land and sea-breezes, with which every yachtsman is acquainted, is simple. In the morning the sun shines alike on land and sea: the land, however, most readily takes up the undulations of heat. The air above the land thus warmed expands, and forms an upward current, while a refreshing breeze comes along the surface from the sea, just as a cold current passed along the floor from the hall.

At nightfall the reverse is the case. The sun withdraws his rays from land and sea: but the land, which was the first to be heated in the morning, is the first to cool in the evening. Soon it is as cool as the sea. Ere long it has become colder than the sea. And the current now sets outwards from the land. We have changed the conditions. We have brought a refrigerator into the dining-room, and the lower cold current now sets outwards into the hall. It is, of course, under ordinary conditions, only the under current which we on the earth feel. The upper current is far above our heads. A French balloonist (Tissondier) rose from Calais into the upper current, and was carried far out to sea; on descending he entered the under current, which bore him safely back to Calais.

The same laws are seen in operation in the Indian Ocean. There for half the year the North-east Monsoon which blows *from* the continent of Asia is the prevalent wind. During the summer, however, it is forced back by a South-west wind, caused by the great upward draught over the glowing plains of Central Asia.

Far away on the broad Atlantic and Pacific Oceans, we may see the same thing on a scale so magnificent as to form a healthy and vigorous circulation for the whole world. In the great system of winds, of which the trade winds are the most constant, we have mighty currents of air which sweep from pole to pole, and are the very life of the earth over which they pursue their ceaseless course.

Thus the existence of the winds is due to sun-heat.[1]

Let us pause here for a moment to see what we have learnt. We have seen that the waves which beat on our shores, and denude our coast-lines, are due to the winds; that the rivers which cut down trenches into the earth are due to rain, which is itself brought to us as vapour of water by the winds; and we have seen that both the formation of water vapour, and the existence of the winds, are due to sun-heat. This sun-heat is therefore the highest link we have yet reached in the chain of causation. We have also seen incidentally that the sand and clay at the top of the cliff were built up of mud and sand grains, carried down mechanically by rivers to the sea: and that the chalk has been separated by living creatures from the sea-water to which the lime had been carried down in solution by rivers. The question—how came this life upon the earth?—now arises. It will not however be discussed here. It is enough to state that it is almost universally believed by those competent to give an opinion, that all life forms have come into being by a process of evolution from primitive organic germs. It may be noticed, however, that all life, whether vegetal or animal, is made possible only by *solar*

[1] Their direction is modified by the rotation of the Earth.

*energy.* Animals depend on plants, directly or indirectly, both for the food they eat and for the air they breathe. In the absence of sunlight plants would be unable to decompose the vast quantity of carbonic acid which animals breathe forth: and thus *their* source of carbon and our source of oxygen would be cut off.

Another question must now be put and shortly answered. The sand and clay and chalk which form our cliff were laid down beneath the sea; how come they now to form dry land? Now it is clear that one of two things must have taken place: either the level of the sea has been depressed or that the land has been raised. Geologists do not hesitate to say that it is the land which has undergone the change in level, while the sea has remained stationary. The sea is, in fact, more stable, more constant, more ancient than our oldest continents. All land is, on the other hand, subject to changes of level. In the Himalaya mountains shells, which once lived in the sea, are found at an elevation of 16,000 feet above the level of the ocean. The northern part of Scandinavia is even now slowly rising, while the southern portion is undergoing depression. But how? There lies the question.

It is now well known that the Earth is, in the interior, in an intensely heated condition. In deep wells and mines the temperature rises about 1° Fah. for every sixty feet we descend. The melted lava poured forth during volcanic eruptions gives us some idea of the temperature comparatively near the surface. The centre of the Earth must then be hot beyond conception. But it is gradually cooling. Heat is flowing outwards through the crust into space: the cooling of the Earth is accompanied by contraction of the mass of the Earth: and unequal contraction produces areas of depression and elevation.

Is this clear? Perhaps a comparison of great things with small will make it clearer. The human mind seems at times to fail to grasp facts which are, in truth, simple, but which from their magnitude are hard of conception. If, for instance, we stand on a high peak and look out over a portion of a great mountain chain, and see the grand summits standing out along the central ridge, it is difficult to conceive how this grand upheaval could have been produced; and perhaps the mind, wearied with the attempt to grapple with a subject almost too great for its powers, finds relief in the thought, that the mighty elevation was due to some great cataclysm or convulsion of Nature, concerning the cause of which—as a matter beyond our ken—it would be rash to speculate. And if it were then suggested that mountain chains, such as that in the midst of which we were standing, must be the inevitable result of the contraction of a cooling globe, it may be that our understanding would reject a conclusion which it could not at once grasp.

But if when we have left the mountain top, we take up a withered apple of last year's growth, the consideration of its surface may help us to understand that which before was so hard to comprehend. When we plucked that apple, a year ago, its surface was smooth, and the skin was stretched tightly over the fruit beneath. But since that time the apple has shrunk in size, the fruit having contracted within the skin, which, no longer tight and glossy, is now wrinkled and puckered up.

But just as in the apple, so too in our planet, there is an inner portion which is contracting, and an outer portion which does not shrink: and as surely as the earth is losing heat by radiation into space, her mass contracting and her size growing less, so surely must the outer portion become puckered up, the most prominent wrinkles forming what we call mountain ranges.

While *sun-heat,* therefore, enables rain, rivers, and the sea to denude the land and to combine in the formation of new continents, *earth-heat* causes a fresh supply of land to be raised above the waters. Were it not for this earth-heat England, as already mentioned, would during the course of geological time be entirely washed into the ocean of geological bankruptcy. All geological action, except that due to the tides, is brought about by sun-heat or by earth-heat.

Before inquiring what is the cause of this sun-heat and this earth-heat, there is one more question to be answered. Of what does the air, the water, the cliff, ultimately consist? Are earth, air, and water, as the ancients believed, elements? No. The air is composed chiefly of a mixture of a gas called Nitrogen with one-fifth of its volume of Oxygen. It is not difficult, as will be seen in Professor Huxley's book, for the chemist in his laboratory to separate these two gases. Nor has he much difficulty in splitting up water into the two gases oxygen and hydrogen; while the further task of ascertaining of what the solid crust of the Earth is composed, though it requires more labour, is by no means beyond his powers. But whereas water contains but two elements, in the solid crust of the earth there are about sixty-five. But what are these elements? They are simple bodies which resist every effort of the chemist to decompose them into simpler bodies. Many chemists, however, believe that, though we cannot by any means at our disposal thus split them up, this is only because the means at our disposal are limited, and that, at an intensely high temperature, all would be found to consist of one primitive form of elementary matter.

One of the most striking results of modern scientific inquiry is the discovery, by means of the spectroscope, that there exists in the Sun's photosphere some sixteen or seventeen at least of the so-called elements, with which we are acquainted on the surface of our earth. Herein lies one of those many bonds, by which we are connected with our central luminary. The cause of these bonds; the origin of sun-heat and earth-heat; and of the Sun and the Earth themselves, now require elucidation.

According to the now-generally-accepted theory, known as the Nebular Hypothesis of Kant and Laplace (and it must be noted that we are here passing from the well known to the less known), our solar system was formed from a diffuse nebulous mass. We must imagine that this rotating spheroid mass once extended to the furthest limits of the solar system; beyond the orbit of Neptune. It radiated heat freely into space, and under the force of gravitation underwent contraction. And as it contracted it left behind it rings of vapour which, breaking up, formed secondary rotating spheroids, themselves contracting, themselves leaving behind them rings, forming tertiary spheroids, themselves passing in their orbits round the central mass. That central spheroid mass is the Sun; one of the secondary rotating spheroids is the Earth, the Moon being a tertiary spheroid. The Earth-planet thus formed was gaseous; but as time rolled on, it passed through the liquid state, to the more or less solid state, which it at present possesses.

Sun-heat is therefore the result of the condensation of the primary spheroid: earth-heat the remnant of that produced by the condensation of a secondary nebulous spheroid.

And now comes the question, how was the rotating nebulous spheroid formed?

If we take a small piece of lead and deal it a number of heavy blows with a hammer, we shall find that the lead becomes hot. If we continue to hammer for ten minutes, we shall find that the lead becomes too hot to hold. Now what is the cause of the heating of the lead. Simply this: when the lead is struck, the motion of the hammer is suddenly stopped: but the motion is taken up in a new form by the particles of the lead, and this new form of motion is heat. The visible motion of the hammer is converted into the invisible molecular motion of heat: for heat is simply the rapid vibration of the ultimate particles of matter.

When a bullet is shot from a rifle against an iron target, the rapidity of the motion is suddenly arrested; heat is developed; and this heat may in some cases be sufficient to melt the point of the bullet. In the same way the immense iron shot, hurled from our modern pieces of ordnance, cannot fail to be intensely heated, when they strike against the sides of such a ship as the *Inflexible*. It is quite conceivable that a shot or bullet of lead might be projected with such violence as to be, not only fused, but converted into vapour on striking the target. For when the motion of heat becomes extremely violent, the particles of matter are shaken asunder, and a vapour is formed.

We may take the velocity of a rifle bullet to be 225 feet in a second. The velocity at which the Earth moves through space, as she travels round the Sun, is about 19 miles in a second. If we imagine that the Earth were suddenly to strike a huge target, the heat generated would be sufficient, not only to fuse the Earth, but to reduce it in great part to vapour. "The amount of heat thus developed would be equal to that derived from the combustion of fourteen globes of coal, each equal to the Earth in magnitude. And if, after the stoppage of her motion, the Earth should fall into the Sun, as it assuredly would, the amount of heat generated by the blow would be equal to that developed by the combustion of 5600 worlds of solid carbon."

Now, it is supposed by Dr. Croll and others (and here, be it noticed, we pass to the still less known: to the purely hypothetical, but still conceivable), that the nebulous mass from which the solar system has been evolved resulted from the collision in space of two vast masses moving at great velocity. Each of these masses may be supposed to have developed from a nebulous mass, in the same way that the solar system has itself developed. Such nebulous masses were endowed with that high form of energy, which may be termed, generally, the energy of separation. But we have seen that this and all other intermediate forms of energy tend to run down, and be degraded to heat uniformly distributed throughout space. Some men of science tell us that this will be the ultimate condition of the energy of the universe. They tell us that the planets will fall into the Sun, and that thus the matter of the solar system will be aggregated into one mass: that this mass coming into collision with another mass similarly formed will produce the nebulous spheroid from which another system greater and grander than ours will be formed: and that so the same thing will go on until all the matter of the universe is aggregated into one mass, and all the energy of the universe is converted into uniformly diffused heat.

But here we have transcended the powers of the human intellect. We have reached that thin atmosphere in which we can no longer build. We have traced the chain of causation as far as we are able. We have reached the Unknowable. When we seek to go further: when we inquire what is *matter*, what is *force*, what is the *ether* through which force acts on matter, what is the *space* in which co-existences are manifested, and the *time* in which sequences are manifested: when we inquire what is consciousness, what is the *thought* by which we are able to trace to some extent the chain of causation, we are met by alternative contradictories. We are in the presence of the Mystery of Mysteries. Let us humbly, modestly, truthfully confess our ignorance.

It may, perhaps, be said that there is much in the foregoing pages that is quite out of place in the Geological Magazine—much about wind and aqueous vapours, the Nebular Hypothesis and the Unknowable. But is it out of place? If there be any truth in my opening paragraph—that just as an artist has now and again to view his picture from a distance, so does the man of science have from time to time to take a comprehensive survey of his subject—No. In any consideration, however imperfect, of the work which Geology is doing for Modern Philosophy, we must weave that work into the general picture presented by the study of Nature. This I have attempted to do. In the first place I have endeavoured to point out the law of causation; that all that we see about us has been *caused* in some way or other. In most cases, from the nature of the subject, this law of causation has been illustrated qualitatively: but in the case of the formation of water-vapour the quantitative truth of the law has been indicated; and the law of the conservation of energy briefly alluded to. In the second place I have tried to show, as far as was possible in the space at my command, how the crust of the Earth has been built up by the mechanical agency of rivers, forming deltas, and the vital agency of simply-constituted creatures. By these two agencies nearly all the rocks have been formed, with the exception of salt, and, perhaps, magnesian limestone, which are due to chemical agency. By the action of earth-heat and other causes, however, some of these rocks have been so altered that their original source is scarcely, if at all, recognizable. How this earth-heat has raised the strata, thus formed beneath the sea, above the waters of the ocean, has been pointed out; and the action of the sea-waves, and of rain and rivers in carving out the face of the country, horizontally and vertically, has been indicated. In tracing the chain of causation from the well-known to the Unknowable, I have not followed the example set by Prof. Huxley in the excellent little book which bears the same title as this article. In these days, however, when we hear so much of the "pride of Science," it is well to point out that in the study of Nature we reach at last ultimate questions, with respect to which we must one and all confess with modest humility that we are and must be ignorant. Finally, in making each fact the effect of one which had gone before it, in time, and the cause of one which followed, I have aimed at that *organization* of knowledge, without which any number of accumulated facts are but isolated pieces of general information.

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## II.—On the Nomenclature of *Saurocephalus lanciformis* of the British Cretaceous Deposits: with Description of a New Species (*S. Woodwardii*).

By William Davies, F.G.S.,

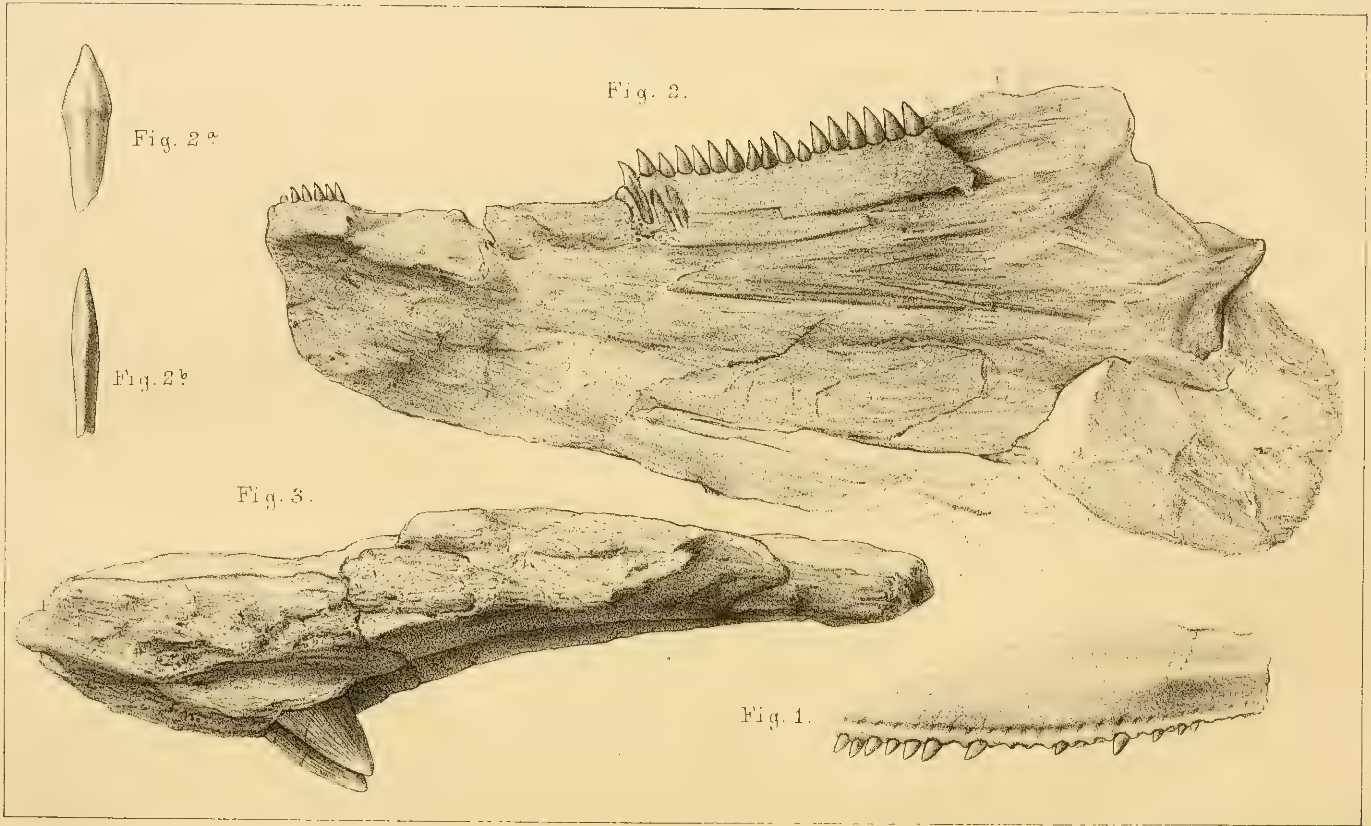
of the British Museum.

(PLATE VIII.)

Dr. Mantell, in his classical work, the "Fossils of the South Downs," figured two large compressed and lanciform teeth[1] preserved in his collection and obtained from the Chalk at Lewes, as respectively the teeth, of an unknown fish and of a species of *Squalus*. Similar teeth, and from the same collection, were subsequently figured and described by Prof. Louis Agassiz,[2] who, from external characters chiefly, considered them to have belonged to a Sphyrænoid fish, and he referred them to an American species founded by Dr. Harlan upon portions of jaws with teeth *in situ* found in a Cretaceous deposit in the State of New Jersey, but described by him[3] as remains of a Saurian, and to which he gave the name of *Saurocephalus lanciformis*. At the time when Agassiz referred these teeth to Harlan's species, and determined their ichthyic character, he had not seen the American fossils; but he states that these conclusions were subsequently confirmed by Prof. Owen's description and drawings of the microscopic structure, and of teeth of the natural size of the *Saurocephalus lanciformis*, Harl., in his "Odontography," p. 130, pl. 55. But Prof. Owen's researches were made upon a genuine tooth of the American fossil sent to him by Dr. Harlan, and not upon an English specimen.

For some years after the publication of Agassiz's work the species

[1] *op. cit.* pl. 33, figs. 7 and 9.
[2] Recherches Poissons Fossiles, tom. v. p. 102, pl. 25 *c*, figs. 21—29.
[3] Journ. Acad. Nat. Sc., vol. iii. p. 337, pl. xii. figs. 1—5.




C. L. Griesbach del. et lith. W. West & Cº imp.

Figs 1. & 2. Saurocephalus Woodwardii, W. Davies, Chalk, Maestricht.
Fig. 3. Erisichthe Dixoni, Cope, Chalk, Kent.

was known only by isolated teeth, which are far from rare in the Chalk and the so-called Upper Greensand of Cambridge; specimens also occur, though not so abundantly, in other British Cretaceous deposits. Ultimately a fine fragment of a lower jaw came into the possession of the late Dr. Bowerbank; while a portion of a maxilla was obtained by Mrs. Smith of Tunbridge Wells, both being from the Chalk of Burham, Kent.

These specimens and some detached teeth in his own collection were figured by Mr. Dixon;[1] who also states that he has "a portion of an upper jaw with two teeth," in his possession; and following Agassiz he refers these remains to the *Saurocephalus lanciformis*, Harl.

It may be stated here, that all these interesting and instructive specimens from the respective collections of Dr. Mantell, Dr. Bowerbank, Mrs. Smith and Mr. Dixon, have been obtained for, and are now preserved in the National Collection.

Mr. Dixon also figures[2] and notes a bony rostrum, which had been obtained by Sir Philip Grey-Egerton, whose practised eye recognized it as the consolidated and prolonged præmaxillæ of the same species of fish to which the remains under consideration belong. Very recently, I have seen a paper published in 1857 by Prof. Leidy, of Philadelphia,[3] in which he contends that the teeth referred by Agassiz to *Saurocephalus lanciformis*, Harl., do not belong to the species described by Dr. Harlan under that name, but that they appertain to a very different fish, and in support of his position Prof. Leidy re-figures and describes the original specimen upon which the species was founded. A glance at the figures is sufficient to show that the remains of the English and American fishes, which have hitherto been considered as generically and specifically the same, do in reality belong to two distinct genera. It seems strange that so important a paper should have been overlooked or been but little known to English ichthyologists, as in all collections I have seen, this particular form of tooth and also the rostral bones are invariably labelled as *Saurocephalus lanciformis*, Harl. The isolated teeth and jaws, figured in the respective works of Agassiz and Dixon, Prof. Leidy refers to a Sphyrænoid fish which he names *Protosphyræna ferox*, and he further states, that the rostral bones have no relation to these jaws and teeth, but pertain to a Xiphioid fish, which he designates *Xiphias Dixoni*. It is due to Prof. Leidy to state that these conclusions were derived from the published figures alone, and not from a study of the fossils.

With a view of testing these conclusions preparatory to re-labelling the specimens in the National Collection, I carefully examined and compared all the English types of the species which have been figured, not only with each other, but also with many other specimens, more or less perfect, in the same collection; and I

[1] Geol. and Foss. of Sussex, p. 374, plates xxx. fig. 20, 21; xxxi. fig. 12; xxxiv. fig. 11.

[2] *op. cit.* p. 374, pl. 32*, fig. 1.

[3] Remarks on *Saurocephalus* and its Allies, Trans. Am. Phil. Soc. vol. xi. p. 91.

have no hesitation in stating, that the isolated teeth, portions of jaws and rostral bones do appertain to the same species of fish. The enamel coating of the crown, and the form and structure of the rostral teeth, are the same in character as the teeth in the maxilla and mandible; each has a well-developed, laterally compressed crown, with long fangs, adapted for insertion in distinct sockets; and, moreover, the well-ossified and somewhat massive bones of the mandible correspond in structure, external ornamentation, and even in condition of preservation, with the same elements of the rostrum. This conclusion is also supported by the fact that wherever the isolated teeth are found, there are also found portions, more or less perfect, of rostra. Associated in the same deposits are frequently obtained coalesced caudal vertebræ similar to, but less symmetrical, and also shorter, higher and thicker, than the consolidated caudal vertebræ of the *Tetrapterus* These vertebræ I have long regarded as belonging to the *Saurocephalus lanciformis*, as hitherto understood, and have so named them in the National Collection. It was a simple deduction, derived from the fact that a fish armed with such a powerful weapon of offence would have had, to render that weapon effective, an equally powerful organ of propulsion through its native element. And such coalesced vertebræ we find in the tail of *Xiphias* and other recent fishes. In the same deposits frequently occur either singly, or in displaced groups, some long bony and unarticulated fin-rays, which probably appertain to the same species.

That the teeth, in form and mode of implantation in distinct sockets, simulate the teeth of a Sphyrænoid fish, is apparent, but no fishes of this family have the premaxillaries consolidated and prolonged into a bony rostrum; neither have any of the long-beaked fishes of the Scomber-Esocidæ, in which family these remains have latterly been classed. Again, the pair of backward-pointing teeth of the rostrum, with the well-developed armature of the maxillaries and dentary bones, and also the abrupt termination of the mandibular symphysis, armed with three strong teeth on either side, two of which are horizontally directed; preclude these remains from association with *Xiphias*, in which genus the jaws are all but edentulous, and the mandibular symphysis acutely pointed.

Therefore, neither of the generic names proposed by Prof. Leidy are applicable to these remains, but having included in *Protosphyræna* two species that are generically distinct, viz. the species under consideration, and the *Saurocephalus striatus*, founded by Agassiz upon mere fragments of two jaws, having respectively five and three teeth *in situ;* and these, not being inserted in sockets, are clearly not referable to *Saurocephalus*, therefore Leidy's genus might be retained, provisionally, for the *S. striatus* of Agassiz. It is thus evident that the British fossils hitherto referred to *Saurocephalus lanciformis* are types of a new genus.

Prof. Cope, in 1872, founded his genus *Erisichthe* upon some remains found in a Cretaceous deposit in Kansas; these he subsequently figured in his larger work on the "Cretaceous Vertebrata of the West."[1] They consist of a maxillary, supposed premaxillaries, and the anterior portion of a left mandible; and so alike are the maxillary and mandible to the specimens figured by Dixon that there could be no doubt as to their being generically the same if we could assume that Cope had erroneously determined the bones he refers to the premaxillaries; but if he is right, they cannot be correlated, for in the American species the premaxillæ are not prolonged into a bony rostrum, a feature not mentioned by him as characteristic of this, or even of any other species described in the above-mentioned work. Yet it would seem as though he had a doubt as to the correctness of his interpretation of these bones, for he does not refer to them in his diagnosis of the genus nor in his description of the species. The maxillary bones, he states, "are sub-triangular in form, and support three or four large lancet-shaped teeth at the middle of their length. There are no teeth beyond them; but, on the deeper side, there are several small lancet-shaped teeth."[2]

The maxillary figured in Dixon, but of which no description is given, is also sub-triangular in form, but much deeper in proportion to its length than the *Erisichthe nitida*, Cope; the surface having an irregular rugose ornamentation. It shows a continuous series of seven lanciform and equidistant teeth, increasing in size from the anterior tooth to the fourth; this, and the posterior teeth, appear from the alveoli to have been of uniform size. Three teeth are *in situ*, viz. the first, or anterior, the fourth and sixth, the others being represented by the alveoli alone. More or less deeply seated in each of these are the apices of successional teeth. It also differs from *E. nitida*, insomuch that it has no outer row of small lancet-shaped teeth. The anterior termination of the bone is wanting; it measures in length three and a half inches, and one inch and a half at the deepest part between the sixth and seventh alveoli, the premaxillary sutural margin being entire.

The anterior portions of the mandibular rami, having regard to specific differences, are so alike in the respective drawings of Cope and Dixon, that they might be assigned without a doubt to the same genus, were it not for the other fragments which are referred to it by Cope. His description of this bone is as follows:—

"The teeth on the greater part of the dentary are intermediate in size between the large and small ones of the maxillaries; they stand on the outer edge of a broad horizontal alveolar plane. There are three large teeth in a series at the end of the dentary on the outer side; they have been lost, but their bases are broader ovals than those of the maxillary bone. On the middle line of this part of the dentary is a close series of small compressed teeth with striate enamel, standing on a ridge of the bone; they leave the last large tooth to the outer side, while on the inner side stand two or three lancet-shaped tusks of a short row further back."—*op. cit.*, p. 218.

The characters of the specimen from Kent are thus defined in Dixon's work:—

[1] Report of the United States Geological Survey of the Territories, vol. ii. 1875.
[2] *op. cit.* p. 218.

"The finest specimen of this species hitherto discovered belongs to Mr. Bowerbank; it shows the extremities of the two rami of the lower jaw; the dentary bones thicken out as they converge to the symphysis to give space for the implantation of six large lanciform teeth, which project forwards nearly in a horizontal direction; the dentary bone immediately behind the symphysis is armed on its inner edge with strong laniary teeth; the two hinder ones being on either side considerably larger than those that precede them; the specimen is broken off a short distance from the commencement of the outer row, the anterior teeth of which are small."[1]

We have here many essential points in which the two specimens agree, the main points of difference being the anterior row of small lancet-shaped teeth upon the outer border of the dentary bone in the American species, but which are not present in the British specimen, which has the anterior teeth of the dentary bone in one continuous series, with smaller teeth in advance of the larger; the small teeth of the outer border commence about half an inch behind the last laniary tooth of the inner border.

To the above description may be added the satisfactory evidence of the mode of succession of the teeth. This is shown by the bases of the first laniaries, as also those of the upper and horizontal teeth of the symphysis on either ramus of the mandible having been absorbed to make room for the successional teeth, the apices of which are present in each alveolus excepting that of the right laniary, which has been lost; they abut against the absorbed portions of the fangs, and are thus developed, as in *Mosasaurus* and other Lacertians, on the outside, and not within the pulp cavity of the mature tooth.

I had written the foregoing remarks, when my friend Mr. E. T. Newton, F.G.S., of the Jermyn Street Museum, to whom I had shown a portion of the manuscript, very kindly called my attention to a paper "On the genus *Erisichthe*," published in 1877, in the sixth Bulletin of the U.S. Geological and Geographical Survey, a copy of which he had received from Prof. Cope; and I publish them as an instance of not uncommon occurrence, of an independent conclusion derived from an actual study of special objects, in some degree confirming what had already been accomplished by other investigators.

In this paper Prof. Cope has identified and described three species of *Erisichthe* from Kansas, and concludes with the following paragraph: "A fourth species has been found in England, and figured by Dixon in the 'Geology of Sussex.' The portions represented in this work are the mandibles, which resemble those of *E. nitida*, and which were supposed at that time to belong to a species of *Saurocephalus*. A muzzle, perhaps of the same species, was regarded as a Sword-fish, which was called *Xiphias Dixonii* by Agassiz." This is an error; the name, as we have seen, was given by Leidy. He continues, "It should be now termed *Erisichthe Dixoni*."

With regard to the genus, he remarks that "*Erisichthe nitida*, Cope, was originally represented by a few portions of the skull; among other pieces, the premaxillary and dentary bones being present. The

[1] Dixon, Geol. Suss. pp. 374, 375.

latter element was correctly determined, but the premaxillary was called maxillary in my description." Having obtained another specimen from Kansas, he continues, "From this and other specimens I discover that the anterior portion of the skull, probably the ethmoid bone, is produced in a long beak, in general form similar to the sword-like snout of the Sword-fishes of modern seas." The prolongation of the ethmoid into a long snout is an important discovery, as it clears the difficulty in regard to the bones previously referred to the premaxillaries. He continues, "The specimen above mentioned includes also the maxillary bones, so that their true character is now clear. A remarkable feature of the genus is displayed in the mandibles. Each of these is compound in the region usually composed of the simple dentary bone. It there consists of three parallel elements, an internal and an external embracing a median element. The inner bears a band of teeth *en brosse* on its inner and superior aspect, and the external a few teeth of similar character, on its superior edge. The large lancet-shaped teeth are borne by the middle element, excepting some of the largest near the symphysis. Two of these on the inner side of the ramus originate in the internal bone."

The mandible figured by Dixon has but two parallel elements in each ramus, and bears no inner "band of teeth *en brosse* on its inner and superior aspect;" proving that the number of the elements in the region of the dentary bone is only of specific and not of generic value. Other points of specific differences in the respective mandibles I have previously mentioned. Prof. Cope further states that, "anterior to the premaxillary bones, on the inferior aspect of the ? ethmoid, is situated a pair of large, compressed, double-edged teeth, whose alveoli are close together. Only one of these teeth is in functional service at a time." Here again, supposing this to prove a constant character in the American fossils, the species of the two countries are not in harmony; for in Mr. Dixon's collection is a proximal portion of a rostrum, referred by him to the upper jaw, in which both teeth are preserved intact; they are nearly equal in size and fully developed (Plate VIII. Fig. 3); and in another specimen in the British Museum, although the crowns are broken, and one tooth is larger than the other, yet they demonstrate clearly that they were both sufficiently projected beyond their respective alveoli as to have been in functional service together. In other imperfect examples in the same collection, the fangs show that the lost crowns of the teeth must have been well if not equally developed. And in all, one tooth, the largest, is slightly in advance of the other. The rostra are hollow for a large portion of their length.

Prof. Cope, to whom we are largely indebted for his original investigations on the Cretaceous fossil fishes, refers *Erisichthe* to his family *Saurodontidœ*, in which group of fishes, species of most of the genera are to be met with in the Cretaceous formations of England.

*Saurocephalus lanciformis* will, therefore, excepting as a synonym, have to be excluded from the catalogue of British fossils, and the remains which have hitherto borne the name will henceforth appear in the corrected lists thus:

*Erisichthe Dixoni*, Cope (sine descrip.); Bull. of the U.S. Geol. and Geog. Surv., vol. iii. 1877, p. 821.
*Saurocephalus lanciformis*, Harl.; Agassiz, Rech. Poiss. Foss., tom. v. pt. 1, p. 102, pl. 25c. figs. 21–29. Dixon, Geol. Suss., 1850, p. 374, pl. 30, figs. 21, 21a–d. pl. 31, fig. 12, pl. 32*, fig. 1, pl. 34, fig. 11.
*Protosphyræna ferox*, Leidy, in part (sine descrip.); Trans. Amer. Phil. Soc., 1857, vol. xi. p. 13.
*Xiphias Dixoni*, Leidy, in part (sine descrip.), *op. cit.*

All the European species referred to *Saurocephalus* by continental authors having been founded upon isolated teeth, similar in character to those erroneously referred to the genus by Agassiz, will have to be transferred to *Erisichthe* or some allied fishes. Nevertheless, there is evidence that *Saurocephalus* is a European genus; for among the fossil fishes from the Upper Cretaceous beds of Maestricht, in the Van Breda collection in the British Museum, are remains of an undescribed species. They are contained in a split block of the well-known friable matrix, which expose on their opposing surfaces the greater portion of a ramus of a mandible with teeth. Since its acquisition by the British Museum, a maxillary and some bones of the head which were present in the matrix have been developed, but unfortunately the bones are in too fragmentary a condition to be satisfactorily determined. The maxilla is also imperfect, and is so placed that the form and dimensions of so much as is preserved cannot be ascertained, for the anterior end underlies the dentary bone, at right angles and in immediate contact with it; the upper sutural margin also, if present, is imbedded in the matrix among the crushed bones of the head, but fortunately, as regards the satisfactory determination of the genus, it shows the inner and most important view. The length of the alveolar border as seen is $2\frac{1}{4}$ inches, and the greatest vertical depth of the bone exposed is 7 lines. It contains twenty teeth, the crowns of some are broken, but those of the first eight are entire, and some are represented by the apices of successional teeth just emerging above the margins of their respective alveoli. The teeth are closely set, having comparatively short depressed crowns with long bases. The inner side of the alveolar border is slightly depressed to a vertical depth of about one line; about midway along this depression, and opposite to the vertical axis of the teeth, commences a series of short oblique notches, which terminate in foramina upon the raised portion of the bone. These foramina are, according to Leidy, characteristic of the genus, their function being the nutrition of the successional teeth. It differs from the maxillaries figured by the same author in being intermediate in size between *Saurocephalus lanciformis* and *S. Leanus;* the apices of the teeth are also longer in proportion to their breadth than in *S. lanciformis,* and this last species does not appear to have any foraminal notches; those in *S. Leanus* are straight, and have their origin at the alveolar margin; whilst in our specimen they are oblique, and commence about midway from the margin.

In splitting the block the dentary bone was unfortunately divided, portions adhering to each counterpart. It is imperfect, insomuch as neither the symphysis nor the articular bone are complete; the angular bone is also imperfect, and the lower marginal border is not clearly defined: yet enough is preserved to enable us to form an approximate estimate as to its original size and form. The fragment is 6 inches and 2 lines in length, of which, about $4\frac{1}{2}$ inches was occupied by the dental alveoli; at a distance of 4 inches from the symphysis it has a vertical depth of 2 inches and 4 lines, and from this point it tapers to a depth of only 10 lines at the symphysis. Upon one block, and occupying a space of 1 inch and 8 lines of the posterior half of the dentary margin, are preserved a consecutive series of 17 entire teeth, one just emerging from its alveolus; they are closely set, and gradually increase in size from the front to the back, the anterior tooth being 4 lines high, and the last having a height of 6 lines, the crown being $2\frac{1}{2}$ lines high, and in antero-posterior breadth 1 line at its base; these dimensions seem to be about the relative proportions of the crown to the fang in all the teeth; they are compressed and lancet-shaped, and the enamel is very finely striated. Each fang has a central shallow vertical sulcus, which is continued into the base of the crown, but they are not so distinctly facetted at the sides as are the teeth of *Saurocephalus lanciformis*. Anterior to, and also behind this series of teeth, the alveolar region of the dentary is broken, so that we cannot with certainty estimate the number of teeth the mandible contained.

Upon the counterblock are preserved the imperfect angular bone and the symphysial end of the mandible, which supports the first five teeth; they are separated by a considerable interval of the broken alveolar border from the other series; these anterior teeth are much smaller, the fifth, or last tooth, which is wholly exposed, being but 2 lines in height. They thus agree in their relative proportions with regard to the gradual increase in size of the teeth from the front to the back of the mouth. The mandible is deep and laterally compressed, the bones being very thin; the articular bone is comparatively short, but its sutural margins are obscure; it shows the articular notch. A portion of a quadrate bone is present, of which, little more than the articulating condyle is preserved.

The bones of the head, as previously stated, are too fragmentary and displaced for their characters to be accurately defined.

It is with much pleasure that I dedicate this new species to my friend, Dr. H. Woodward, F.R.S., etc., by whose exertions this specimen, with many other fine fossils from the Maestricht beds forming the Van Breda Museum at Haarlem, were secured for the National Collection.

## EXPLANATION OF PLATE VIII.

FIG.

1. Inner view of the maxillary of *Saurocephalus Woodwardi*, showing the foramina and notches, natural size.
2. Outer view of the left mandibular ramus of the same, drawn from the two blocks of matrix, natural size.

2*a*. Enlarged outer view of the anterior tooth of the posterior series, 3 times nat. size.

2*b*. Inner view of the same tooth.

3. Proximal end of muzzle of *Erisichthe Dixoni*, showing the pair of rostral teeth.

## III.—On the Possibility of Changes in the Earth's Axis.

By Rev. E. Hill, M.A., F.G.S.
Fellow and Tutor of St. John's College, Cambridge.

THE possibility of change in the position of the Earth's axis seems periodically to attract attention. This is happening now. Professor Haughton has written upon this subject, Sir William Thomson has alluded to it, while two important papers have been read upon it, one by Professor Twisden before the Geological Society, the other by Mr. George H. Darwin before the Royal Society. This article is an endeavour to exhibit to the general reader the assumptions with which they have started, and the results they have obtained.

The phrase "change in the Earth's axis" is susceptible of several meanings which do not coincide in like changes of climate. The Earth may be supposed to be tilted, so that its axis of rotation should make a new angle with the plane of the ecliptic. Or the Earth may retain the same shape, but be caused to rotate about an axis holding a different position in its body. Or—the change most easily conceived by a geologist—the shape may be supposed to change by expansions and contractions, so that the axis of figure shall occupy a new position in the body of the earth, which however shall continue to rotate about an axis the same in direction as before. Or lastly, the shape may thus change, and the axis of rotation change also. They are however to separate in their change, for if they kept together this case would agree with the first mentioned. Imagine the Earth a huge orange, spinning, impaled by some giant of Hindoo mythology on a correspondingly gigantic knitting needle. The first change would be produced by his tilting the needle, the second by impaling the orange differently, the third by squeezing it into a new shape, while the fourth would naturally result from the difficulty of holding the needle steady during this operation.

There are two kinds of alteration of climates which can thus be produced on the Earth. If the axis of rotation were tilted (as in the first case), all places would have the same latitude as they now have, all places on the same latitude would receive heat and light alike, but they would not receive these in the same way as they do now. The lengths of the seasons, and the Sun's midsummer and midwinter altitudes, would be changed. The Arctic Circles and the Torrid Zone would change their breadths. An alteration of climates would result, and the alteration would be of like nature on all sides of the Pole. What that alteration would be is not so easy to say. Probably a tilt making the axis more nearly perpendicular to the plane of the Ecliptic would render the Polar climate milder. This would agree with the supposed condition of the Miocene age. But it will be seen hereafter that this change is exceedingly difficult to produce.

The other kind of alteration would result were the axis of rotation to retain its present direction in space but to occupy a different position in the body. The orange would be impaled differently on the knitting needle. The Poles would not be at the spots where they now are. The parallels of latitude would lie on different circles, for latitude depends on distance from the pole of rotation. The light and heat received by all places on the same latitude would be equal, and as much as that latitude now receives, but any one place would not receive the same as before. The latitudes of places would be changed. There would be as hot a Torrid Zone, but it would occupy a different belt of the surface. There would be as wide an Arctic Circle, but its centre would be at another spot. The changes in climate would not in this case be the same on all sides of the Pole. On the side nearer the new Pole they would be made more arctic, more temperate on the side remote. Had the Pole been thus shifted in a past age, traces should somewhere remain of the then ice-cap. Geologists however say that at present none are known.

Professor Evans, in his presidential address to the Geological Society, asked mathematicians whether the elevation of a certain belt of land would not carry the Earth's axis of figure 15° or 20° away from its present position, and whether ultimately the axis of rotation would not again coincide with the axis of figure. That is, he supposes the earth deformed, and asks whether this will not cause such a change in the rotation axis as will end in a tilt of the earth as final result.

Professor Twisden's paper, printed in the last number (133) of the Quart. Journ. of the Geol. Soc., answers this question. He takes Professor Evans' supposition of an elevated zone of land, and calculates the deformation to which it is equivalent. He shows that instead of shifting the axis of figure 15° or 20° from its present position, it would produce only about 10′ of angular displacement, and that to obtain so great a change as even one degree, the zone of land must be elevated no less than five miles. He then discusses what would result from a separation between the axis of figure and rotation. He points out a startling consequence, namely, that two vast tide-waves would sweep the earth, submerging the Equator every 150 days to a depth of six miles or more. He adds some interesting remarks on the tendencies to alteration which the present river-systems may be producing, pointing out that not only are their effects extremely minute, but that many of them tend to compensate for each other.

The condition necessary to produce Professor Twisden's tide-waves is that the Earth's axis of figure should occupy a position different from that of her axis of rotation. Now expansion and contraction, upheaval and depression, denudation and deposition, must necessarily deform the Earth and displace her axis of figure. But this alteration will be produced gradually. What will happen meanwhile to the axis of rotation? Can it be supposed to remain unchanged? To this question an answer is provided by Mr. Darwin's paper.

The conclusions of this paper are reached by rather complicated analysis. A simpler process suggested by Sir William Thomson is given in an appendix. The main results may be obtained by general reasoning without symbols. But in every case a considerable knowledge of Rigid Dynamics is required; so the non-mathematical reader must, I fear, take the statements on trust. Mr. Darwin considers the case of the earth undergoing a very slow and small deformation; slow, so that thousands of years are required for the change, and small, so that the change when made shall not have greatly altered the shape. This will shift the axis of figure away from that original position in which it coincided with the axis of rotation. But movements will thus be set up in the Earth such that coincidence will be periodically regained. And the separation between the Poles will be at all times so exceedingly small that for all practical purposes they are coincident. In fact, the distance between the Poles cannot ever exceed about one-third the distance over which the pole of figure would be shifted by these deformations in a period of 300 days. Now this, with such elevations as we at present know, of a few feet in a century or the like, would be a quantity almost microscopic. Thus Professor Twisden's tide-waves cannot arise, since the change required to produce them cannot come into existence.

Having thus settled that the two axes keep together in the body, the next question to be considered is their position in space. Is it altered or not? Do the coincidence-restoring movements bring back the axis of figure to the position in space from which it started, or does the rotation-pole follow the figure-pole in its wanderings? Is the Earth not tilted or tilted? Is not or is the obliquity changed? The calculations show that it is not to any perceptible degree. For instance, the process of production of an ice-cap reaching down to lat. 45° would not alter the obliquity by ·0005 of one second. Hence the deformation will produce a change equivalent to the second case: the orange impaled on the needle differently. It will bring other parts of the Earth into the Arctic regions, while the axis of rotation retains a practically unchanged position in space. The alteration in climate would be of the second kind, one whose evidence might be expected to include some traces of the former ice-cap.

Having thus worked out the effects of Deformation, Mr. Darwin calculates how much deformation can be produced by any conceivable elevation of land. He investigates very skilfully the shapes and positions of regions of upheaval and subsidence which would be most effective for change. He takes the case of an ocean bed 15000 feet deep elevated into a continent 1100 feet high (which is a little above the average), and obtains the new positions of the axis of figure corresponding to various assumed areas of such elevation and like depression of the surface. The possible alteration of position is not great. A continent equal to Africa elevated, and an equal area depressed in the most effective shapes and positions, would produce a change in the position of the Pole of less than two degrees. Moreover, this is obtained on the supposition that the elevation and depression are obtained by the actual removal of matter from the surface of the one area, and its deposition on the other. If we adopt the easier supposition that elevation is produced by the expansion of subjacent strata, depression by their contraction, the resulting change is diminished to a considerable, possibly to a very great extent. If, for instance, the expansion or contraction take place between the depths of 10 and 50 miles, the shift of the Pole will be diminished to less than a sixtieth part of its former amount. If the supposed areas occupy positions other than the most effective, these changes must be still further reduced, and may even vanish altogether.

These calculations are based on the supposition of a practically rigid Earth. If its interior be fluid, Professor Twisden's tide-waves still hold good, for their magnitude depends only on observed quantities. Mr. Darwin's calculations involve Laplace's hypothetical law of density, and obtain results true for a solid globe. But mathematicians seem to consider that even if the interior be fluid, yet as far as change of rotation is concerned, it must behave as if it were rigid. Accordingly the results are unaltered.

Mr. Darwin points out that if alterations in the Earth's surface should produce a separation, however small, between the axes of figure and of rotation, the mass of the Earth would be thrown into a state of stress, which he suggests might be relieved by an earthquake restoring coincidence. Though the strains would be extremely minute, this seems possible. He works out the results of this, and also those of the Earth being plastic, capable of yielding to any stress, and deduces that the pole of rotation would describe a kind of spiral round the point towards which the pole of figure was being shifted by the change. This point he had shown could not be far distant, and therefore the spiral could not be wide. Nevertheless he seems to think that in a plastic globe this cause might lead to considerable wandering of the poles. But with respect to the Earth, he appeals to Sir William Thomson's demonstrations of its rigidity as excluding the hypothesis of plasticity.

Mathematicians may seem to Geologists almost churlish in this unwillingness to admit a change in the Earth's axis. Geologists scarcely know how much is involved in what they ask. They do not seem to realize the vastness of the Earth's size, or the enormous quantity of her motion. When a mass of matter is in rotation about an axis, it cannot be made to rotate about a new one except by external force. Internal changes cannot alter the axis, only the distribution of the matter and motion about it. If the mass began to revolve about a new axis, every particle would begin to move in a new direction. What is there to cause this? When a cannon ball strikes an iron plate obliquely, the shock may deflect it into a new direction. The Earth's equator is moving faster than a cannon ball. Where is the force that could deflect every portion of it and every particle of the Earth into new directions of motion? The cannon ball is slightly and slowly deflected by gravity. But the attraction of the Sun and Moon could produce on a slightly distorted globe no effect essentially different from what they produce now.[1] No other force exists capable of producing any effects at all.

[1] Suppose the Sun's attraction at any instant to be causing in the Earth a beginning of a rotation about any diameter through the Equator. Twelve hours later

Even if geologists will give up asking for a tilt of the axis, and be content with a new shape, still the mathematician asks whether they have realized the Earth's size. 'Its deviation from a sphere is trifling in amount.' In what amount? In figure doubtless. Were its section drawn on this page a microscope would be wanted to distinguish the curve from a circle. But in quantity the deviation is not trifling. The height of the highest mountain and the depth of the deepest sea together do not equal its extent. All the mountain chains added together would not perceptibly increase the volume of the equatorial protuberance. The mass of all the continents reinforced by that of all the seas would not be the fifth part of it. To change the Earth's shape this vast protuberance must be shifted or masked. Where is the power that can shift it, the elevation that can mask it? What are our puny upheavals and subsidences of an ocean here and a continent there compared with a girdle of matter thirteen miles in thickness? Take an extreme supposition. Remove 10,000 feet of rock from the surface of one-half the Earth and spread it over the other half. You could not thereby bring the pole half way to the present Arctic circle. Sufficient changes in the Earth's surface will undoubtedly shift the pole. But will geologists grant the changes that would be sufficient?

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## IV.—The Formation of Till.

By A. J. Jukes-Browne, B.A., F.G.S.

NOTWITHSTANDING the numerous papers which have lately been written on the subject of glacial deposits, there is one question of fact which does not appear to have been satisfactorily decided. I refer to the formation of Till underneath glaciers, concerning the possibility of which somewhat different statements were put forward by two writers in the February Number of the Geological Magazine.

The following passage occurs in Dr. James Geikie's paper on the Preservation of Deposits under Till:—"It is needless to refer one to the petty glaciers of the Alps and Norway to prove that glacier-ice cannot both erode its bed and accumulate *débris* upon that bed at one and the same time. . . . No considerable deposit could possibly gather below alpine glaciers like those of Switzerland and Norway; but underneath glaciers of the kind that invaded the low grounds of Piedmont and Lombardy we know that thick deposits of tough Boulder-clay, crammed with scratched stones, did accumulate."

At a later page of the same Number Mr. G. Linnarsson animadverts upon a portion of Prof. Milne's "Travelling Notes," which have recently appeared in this Magazine, and says—"That, actually, *Till*

this diameter will have turned with the Earth's diurnal motion so as to lie in the same line but reversed. The rotation produced at the former line will be in the opposite direction to that now being caused, and will be neutralized by it. The afternoon will undo the morning's work. This explanation is very insufficient, giving no account of Precession, but it may assist those unacquainted with Rigid Dynamics in comprehending how the Sun may be perpetually drawing the Earth's equator towards coincidence with the Ecliptic, yet never bringing it any nearer.

*is formed*, and rocks polished and striated by glacier-ice, is so well known from observations in the Alps and elsewhere, that I think Prof. Milne himself cannot deny its capability of producing such effects." The italics are mine.

Prof. Milne will doubtless state his own views more fully, and I think he may very fairly claim to have the evidence of Till being formed under Alpine glaciers set before the readers of this MAGAZINE.

In Dr. Geikie's "Great Ice Age," I only find mention of the stones frozen into the bottom of glacier-ice (p. 40), and a theoretical description of the supposed formation of ground-moraine under the Scottish ice-sheet (p. 68). I think, therefore, that many geologists would be glad to have an authentic description of the actual formation of *moraine profonde* at the present day, either in Switzerland, Norway or Greenland. Have the original statements of Agassiz and Charpentier ever been confirmed, and are the facts such as would warrant the creation of such a monster as modern glacialists have constructed out of their *moraine profonde?*

One good observer at any rate replies in the negative; speaking of some retreating Swiss glaciers, Prof. Bonney says,[1] "In no case have I been able to find any deposit resembling Till or Boulder-clay; . . . . by availing myself of crevasses, etc., I have made my way occasionally for some little distance beneath the ice. Nothing has been seen but bare rock with now and then a film of mud or a passing stone."

Dr. Geikie, however, is quite satisfied that no considerable deposit accumulates under Alpine glaciers, and he says, "A mountain glacier is one thing—a glacier extending far into the low grounds beyond the mountains . . . . is another and very different thing." But is the difference more than one of degree? their behaviour, *ceteris paribus*, must surely be the same. Dr. Geikie maintains that the *moraine profonde* will only be formed in any quantity when the glacier reaches the plains beyond the mountains, but the upholders of the glacier erosion theory say that a lake is likely to be formed where a glacier debouches on to level ground. Dr. Geikie has, of course, thought over this difficulty, and can doubtless explain how he reconciles the two views, if indeed he accepts the latter.

Again, the Greenland glaciers are of large size, but can he point to the existence of gründ-moraine beneath them? Those descriptions of Greenland ice which I have had an opportunity of reading seem rather to negative than confirm the supposition of its existence. An excellent account was contributed to this MAGAZINE[2] by Professor Nordenskiöld, who distinctly says that when the ice retires it gives rise to a slope covered with boulders, not to a moraine. Again he speaks of the smoothed, scratched and grooved rocks, showing that the fiords have been widened and cleansed from earth, gravel-beds and mountain detritus by the operation of glaciers (*loc. cit.* p. 365).

There are, however, two peculiar features which are observable along the coast, and have been described by most travellers in

[1] GEOLOGICAL MAGAZINE, Dec. II. Vol. III. p. 197.
[2] GEOLOGICAL MAGAZINE for 1871, Vol. IX.

these regions. The first of these is the strip of border-land which intervenes between the inland ice and the sea-margin, and which is the habitable part of the country; over its surface are scattered occasional ponds and lakelets, it is clothed in summer time with a certain amount of vegetation, and is frequented by many Arctic animals. The second feature consists in the frequent occurrence of clay banks along the shore, and especially in front of some of the larger glaciers. Now have we not in these phenomena some indication of the conditions under which the so-called *interglacial beds* and the so-called *Till* were severally formed?

Prof. Nordenskiöld (p. 409) describes a raised plateau of marine glacial clay, now forming part of this border-land, and covered with a scanty vegetation; suppose this land surface to be gradually submerged again, so that the sea might once more wash against the face of the inland ice, what succession of deposits should we then expect to be produced? would not the land-surface with its occasional fresh-water beds be covered by more or less stratified marine deposits passing up into unfossiliferous glacial clay, in which erratics would be rare or frequent according to the production of icebergs from the ice-wall? and would not the whole series be very similar to that near Woodhill Quarry in Ayrshire, as described by Dr. Geikie at pp. 160–2 of his "Great Ice Age"? The succession of changes which he considers to be indicated by the evidence there found are given at p. 174, and these are exactly what we have just supposed as taking place in Greenland, only that the periods of time would be comparatively short, the changes of climate less extreme, and the upper glacial clay would not be a *moraine profonde*.

In a note at p. 185 concerning the similar succession of beds in Lewis, Dr. Geikie says:—"I thought the beds between the two Tills or Boulder-clays might indicate merely a temporary retreat of the ice during some exceptionally mild years, but subsequent and more detailed observations in the island have satisfied me that the appearances presented by the Drift cannot be thus explained." I think I am not the only reader of this Magazine who would wish to be similarly satisfied. The members of the Scottish Survey are, I believe, unanimous in accepting the moraine profonde theory; those of the English Survey, who are now mapping the Drifts of East Anglia, are mostly inclined to the hypothesis of the marine or sublittoral formation of Boulder-clay.

It is worthy of note that these two theories lead to entirely opposite conclusions regarding the periods of elevation and submergence. According to one set of observers the land is high and elevated at the very same time when the others believe it to have been low or submerged.

Must we ever thus agree to differ, and is there no possibility of a middle course being found, in which we may sail safely between the dangers of icebergs on the one hand and ground moraines on the other? I for one am quite willing to be partially if not entirely converted, but I am still in the sea of difficulties.

If Dr. Geikie favours me with any reply to the above remarks, will he be good enough to say whether he conceives the *moraine profonde* was or was not frozen into the base of the ice, and if so frozen as to move with it, what caused the moraine to be separated and left behind at any point during its descent.

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## V.—Palæontological Notes.

By R. Etheridge, jun., F.G.S.

(Continued from p. 119.)

1. Arbusculites argentea, P. Murray (Edinb. N. Phil. Journ. 1831, vol. xi. p. 147).—Under the title, "Account of the *Arbusculites argentea*, from the Carboniferous Limestone of Inverteil, near to Kirkcaldy, in Fifeshire," a curious paper was published in 1831, by Dr. P. Murray, of Scarborough. The organisms are described as "very delicate vermiform bodies, in fragments of different lengths, shining with metallic lustre, neither articulated nor cellular, and resembling broken bits of silver wire." The author adds, "It would appear to have been an attached Mollusc, dichotomous at first, but afterwards sending out lateral branches, moderately tapering, and with very distant and obscure (if any) articulations, grooved longitudinally, and composed of a bright silvery cortical *case*, and a solid axis of carbonate of lime. . . . It differs decidedly from the Crinoidal animals, which are regularly articulated; and varies nearly in the same degree from the Corallines, etc., by not displaying the cellular structure characteristic of that family." Dr. Murray ultimately places this fossil amongst the Corallines, selecting for it a provisional resting-place in the third order of the first class of Lamouroux.

Amongst the many fossils I have seen from Inverteil I have never been able to recognize any body which would answer to Dr. Murray's description and figure of *Arbusculites argentea*, and, so far as I am aware, it has been entirely lost sight of by all subsequent writers. I shall be glad if any of my fellow-workers in Carboniferous Palæontology, by a study of the original article, can throw any light upon this obscure fossil. According to Dr. Murray's description, the want of articulations and dichotomous nature separate it from the Crinoidea. It may be some form of Polyzoa, but the absence of cells renders it doubtful. The figure given by Dr. Murray at once shows that the fossil cannot be the tubes of Annelida. The description, "resembling broken bits of silver wire," accords better, so far as my knowledge of Carboniferous organisms goes, with the long spines of *Producti*; but in this reference we are again confronted with the dichotomous nature of the fragments.

2. Ichthyolithus Clackmannensis, Fleming (Edinb. N. Phil. Journ. 1853, vol. xix. p. 314, t. 4).—The fact that Prof. Fleming was one of the earliest observers, although apparently subsequent to Agassiz, to describe the well-known Carboniferous fish *Megalichthys Hibberti*, appears to have been generally overlooked. His paper, "Notice of the Remains of a Fish found connected with a Bed of Coal at Clackmannan," and published in 1835, makes it quite clear that Dr. Fleming was perfectly well acquainted with this fish under the above name, obtained "in the course of the mining

operations of the Devon Iron Company, and in the neighbourhood of their works." The specimen consisted of a portion of an individual exhibiting both sides of the body, with a large number of scales in position, which were recognized by Dr. Fleming as "the scales of a fish." The specimen, when slit horizontally, exhibited the remains of the vertebral column. Upon my calling the attention of Dr. R. H. Traquair to this paper, he at once recognized in the figures an unlabelled specimen of *M. Hibberti* in the Museum of Science and Art, Edinburgh, but which he had long surmised formed a portion of the "Fleming Collection," deposited in that institution. The genus *Megalichthys* had been established previously by Prof. Agassiz (Brit. Assoc. Report for 1834, p. 448), and the species *M. Hibberti* indicated in a foot-note attached to the paper in question, "On the Fossil Fishes of Scotland."

3. Corbula limosa, Fleming (Brit. Animals, 1828, p. 426).—The type specimens of this species are preserved in the "Fleming Collection," Museum of Science and Art, Edinburgh, and are from "slate-clay connected with Carboniferous Limestone." *C. laminosa* appears to have been entirely lost sight of by subsequent writers, except Prof. Morris (Cat. Brit. Foss., second ed. 1854, p. 195). I am at present in doubt as to the true generic relations of the species, but it is not unlikely that it may prove to be a *Schizodus*, or closely allied genus. It has the anteriorly incurved beaks of the former.

4. Venerupis Lyelli, Fleming (MS.).—There is also in the above collection a very fine Carboniferous bivalve bearing a label with the above name. So far as I know, Prof. Fleming did not publish a description of it, and I do not find it mentioned in any list. It is a large Edmondiform shell, apparently near *Edmondia rudis*, M'Coy; *E. gibbosa*, M'Coy; *E. quadrata*, M'Coy, or *E. oblonga*, M'Coy. I hope to describe it fully.

5. Pleurotomaria humilis, de Koninck (Foss. Pal. Nouv. Galles du Sud, 1877, pt. 3, p. 325, t. 23, f. 14).—A new form of *Pleurotomaria* was shown me by Mr. John Henderson (Edinb. Geol. Soc.), obtained by him at the Gilmerton Quarry, near Edinburgh. Upon forwarding it to Prof. de Koninck, the latter was kind enough to inform me it was his *P. humilis*, a new form then in course of description from the Rev. W. B. Clarke's collection of N. S. Wales Carboniferous fossils. It has since been published in the above work. The discovery of this species by Mr. Henderson in our Lower Carboniferous Limestone Group is a fact worthy of record.

6. Ascodictyon stellatum, Nicholson and Etheridge, jun. (Ann. Nat. Hist. 1877, vol. xx. p. 464, t. 19, f. 1–6).—The British species of this provisional genus was *A. radiatum*, N. and E. Evidence has now been obtained by Mr. J. Bennie, which will probably indicate *A. stellatum*, N. and E., also as British. A fragment of a Crinoidal stem has scattered over it a number of vesicles united by creeping stolons or fibres, so closely resembling those figured by Prof. Nicholson and myself as the oval young (?) vesicles of this species, that I see no reason, so far as the evidence at my command goes, to doubt the identity of the forms.

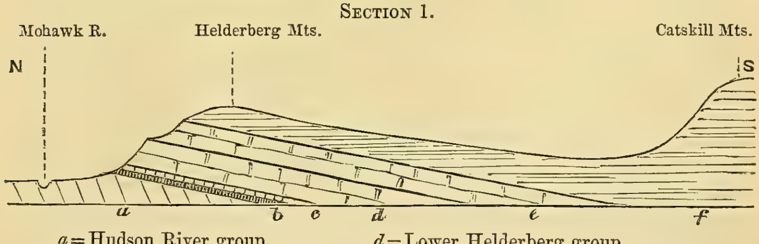
## VI.—On the Correlation of the Lower Helderberg Group of New York.

By C. Callaway, M.A., B.Sc., F.G.S.

I PROPOSE in this paper to give the evidences for the stratigraphical position of this interesting group, both because the task, so far as I am aware, has not been attempted in detail, and because American geologists themselves are not altogether agreed on the subject, some maintaining the equivalence of the group with our Ludlow, while there are a few who regard it as an easterly extension of the Niagara series of Western New York. Having had an extensive practical acquaintance with the fossils of New York, in the State Museum, and having supplemented cabinet study by work in the field, I venture to hope that I may be able to determine the question to the satisfaction of geologists.

1. *Sketch of the group in the typical area in New York.*—The Helderberg Mountains form a low range striking in a comparatively straight line from the valley of the Hudson south of Albany on the east through Albany county to Schoharie county on the west. They present a steep escarpment to the north, overlooking the Mohawk, a western tributary of the Hudson. To the south, the ground gradually slopes downwards for several miles, then rises more abruptly into the bold masses of the Catskills. The base of the Helderberg escarpment generally rests upon the unconformable beds of the Hudson River group. The escarpment itself mainly consists of limestones of Lower and Upper Helderberg age, with a thin basement of Clinton and Niagara rocks, and a considerable capping of arenaceous shales of the Hamilton group. The following cut represents the section from the valley of the Mohawk on the north to the Catskills on the south.

Section 1.

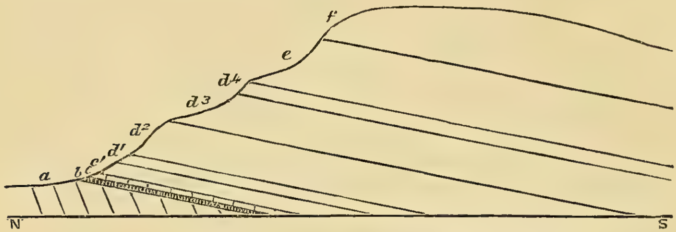



*a* = Hudson River group.
*b* = Clinton shales.
*c* = Niagara Limestone.
*d* = Lower Helderberg group.
*e* = Upper ditto (Lower Devonian).
*f* = Middle and Upper Devonian.

The above section shows the relation of the Lower Helderberg to the formations above and below. The next is on a larger scale, and is designed to display the subdivisions of the group. The section is taken through the escarpment overlooking the village of Schoharie, to the south-west of Albany.

Ascending the escarpment from Schoharie, we find at its base a thin bed of greenish shale charged with iron pyrites, the probable easterly attenuation of the Clinton (Upper Llandovery) series. Forming a thin cornice overhanging the shale are a few feet of coralline limestone, the meagre representative of the Niagara (Wenlock) group of Western New York. We next come to the Water-lime rock, so named from its use for hydraulic cement, a dolomite rendered impure

SECTION 2.




$a$ = Hudson River group.
$b$ = Clinton shales.
$c$ = Niagara Limestone.
$c^1$ = Water-lime group (Onondaga Salt group).

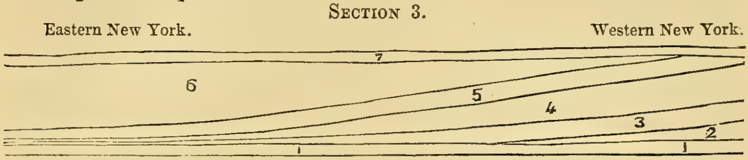
$d$ = Lower Helderberg group:—
$d^1$ = Tentaculite Limestone.
$d^2$ = Lower Pentamerus Limestone.
$d^3$ = Delthyris Shaly Limestone.
$d^4$ = Upper Pentamerus Limestone.
$e$ = Upper Helderberg group.
$f$ = Hamilton group.

by silica, alumina, and iron peroxide. It represents the great saline series of Onondaga county, the Onondaga Salt group, the equivalent of the upper part of our Wenlock series. Next in order we have the four members of the Lower Helderberg. First, a thin band of a clinking limestone full of a Tentaculite, the Tentaculite Limestone. Then comes the Lower Pentamerus Limestone, a massive thick-bedded series, 50 feet in thickness, characterized by the abundance of *Pentamerus galeatus.* The preceding limestone beds form a bold escarpment, in some places falling down in a vertical precipice. Overlying the Lower Pentamerus Limestone is the Catskill or Delthyris Shaly Limestone, a calcareous shale with impure thin-bedded limestones. Being much softer than the limestones above and below, this shale is hollowed out, and forms a gentle slope rising up to the fourth subdivision, the Upper Pentamerus Limestone, a thin band which overhangs the shaly beds in a well-marked cornice. It is characterized by the abundance of another species of *Pentamerus, P. pseudogaleatus,* The different members of the Upper Helderberg succeed, capped by the Corniferous Limestone. A profile of the hill thus shows three bold steps or terraces formed respectively by the Lower Pentamerus, the Upper Pentamerus, and the Corniferous Limestones. With the last of these we have not here to deal.

2. *Stratigraphical evidence.*—Some American geologists have maintained that the Lower Helderberg group is the easterly extension of the Niagara series of Western New York, the equivalent of our Wenlock. This identification appears to be based upon certain palæontological resemblances between the two formations, which I shall discuss farther on. It has probably received support from the fact that both the Niagara of Western New York and the Lower Helderberg of the Eastern end of the State hold a similar relation to the overlying Upper Helderberg Limestone. In the Helderberg range

the Lower Helderberg group occupies the chief space between the Cambro-Silurian and the Upper Helderberg, and this holds good also of the Niagara group in the west. The following section will explain this misconception, and at the same time show the true relation of the deposits in question.

SECTION 3.




7. Upper Helderberg Group.
6. Lower do. do.
5. Water-lime Group.
4. Niagara „
3. Clinton Group.
2. Medina Sandstone.
1. Hudson River Group.

This section is about 200 miles from east to west. Being drawn from memory, it does not pretend to be an accurate representation of the comparative thickness of the beds. It shows the *relations* of the groups, with an approximation to the thickness, which is all my purpose requires. It will be seen that the Hudson River shales and slates form the basis of the whole succession. The Medina Sandstone is a considerable formation on the Niagara and Genesee Rivers, but thins out towards the middle of the State. The Clinton Limestone and Shales are in force in the same localities, but to the east, in the Helderbergs, it has thinned out to a shale of seven or eight feet in thickness. The Niagara Limestone and Shale thin out in the same direction, and are represented at Schoharie by two or three feet of coralline limestone. The Saliferous or Water-lime group is persistent in varying thickness from west to east. The succeeding Lower Helderberg rocks, however, are the converse of the preceding; and, from a thickness of over 200 feet in the east, thin out entirely towards the western side of the State. The limestone capping of the Upper Helderberg series extends in an unbroken band from east to west, overlapping the Lower Helderberg on to the Water-lime, and, beyond the western boundaries of the State, overlapping the Water-lime on to the Niagara Limestone itself. This section, if accurate, decides the question; and of its accuracy I have no doubt. I have made numerous traverses across it in both eastern and western New York. I have, furthermore, the unimpeachable testimony of Professor James Hall to the effect that he has traced the several formations from east to west, and he has assured me in repeated conversations that the section is substantially as I have represented it. The Lower Helderberg group, therefore, clearly overlies rocks of the Niagara period. It is also distinctly separated from the Niagara by the character of its fauna. The only species known to me as common to the two formations are *Atrypa reticularis* and *Strophomena rhomboidalis*. Of these *A. reticularis* ranges from Middle Silurian to the Carboniferous, and *S. rhomboidalis* from Lower Silurian to the Carboniferous, so that their testimony does not in the slightest degree militate against my position. This evidence is very decisive, when we remember that the two formations compared are similar in lithological composition, both being composed of limestones and calcareous shales; and that both were deposited in the same area. The difference in the facies of the fauna is not, however, so marked as to indicate a very wide break in time. There is a like abundance of the genus *Platyceras*. Many species of Trilobites and Brachiopods are similar, especially in the genus *Dalmannia* amongst the former, and in the genera *Rhynchonella, Meristella, Spirifera, Leptocœlia, Orthis*, and *Strophomena* (*Streptorhyncus*), amongst the latter. Towards the close of the Niagara period, there was an upheaval of the sea-bottom with the formation of salinas and the deposition of dolomite. In the subsequent depression towards the east, the Lower Helderberg beds were deposited. The difference between the two faunas is just what we should expect from this change of conditions and lapse of time.

3. *Palæontological evidence.*—I have endeavoured to show that the Lower Helderberg group overlies, and is distinct in its fauna from, the Niagara rocks. The latter group is the undoubted equivalent of the Wenlock series, so that on stratigraphical grounds the Lower Helderberg would appear to be on the horizon of our Ludlow rocks.

A preliminary difficulty must be first discussed. There are certain fossils, or groups of fossils, which confuse the general evidence of the respective faunas. The Lower Pentamerus Limestone derives its name from the great abundance of *Pentamerus galeatus*. In Britain this form is common in the Wenlock, and occurs less abundantly in the Lower and Middle Ludlow. It is also described by De Verneuil from supposed Devonian limestone in the South Urals. As it is found at a lower horizon in Britain than in America, Professor Hall has intimated great doubt of the correctness of the British identification; but as I have myself collected the species in Wenlock Limestone quarries near Wenlock, I am bound to maintain that it is a Wenlock species. The supposed difficulty is easily removed on the hypothesis of an east to west migration. A much more serious objection to the Ludlow age of the Lower Helderberg is the following. In the Ludlow we have an abundant lamellibranchiate fauna, the genera *Pterinea, Cypricardinia*, and *Goniophora* being especially characteristic. This assemblage does not occur in the Lower Helderberg, but in the Hamilton group it is represented by many of the same genera, and by numerous allied species. In other respects, the facies of the Hamilton fauna is decidedly Devonian. The following analysis of the principal genera and species will set this in a sufficiently clear light. I give only those which are of value for our purpose:—

PLANTÆ.—*Caulopteris, Psaronius, Lepidodendron*, and *Sigillaria* are quoted from the Hamilton rocks of Pennsylvania and New York.

ANTHOZOA.—*Heliophyllum Halli*, Edw. (very common). Quoted in Morris's *British Fossils* under the name of *Strephodes helianthoides*, Goldf., from the Devonian Limestone of Devonshire and the Eifel.

BRACHIOPODA.—*Crania Hamiltoniæ*, Hall. Said by Hall to resemble *C. obsoleta*, Goldf., from the Eifel.

*Orthis Vanuxemi*, Hall, *O. leucosia*, Hall, *O. Penelope*, Hall. All of these closely resemble *O. Michelini*, Leveillé, a Carboniferous form.

*O. Tulliensis*, Vanuxem. Of the type of *O. resupinata*, Martin, of our Devonian and Carboniferous.

*Streptorhynchus Chemungensis*, Conrad. Similar to *S. crenistria*, Phil., of the European Devonian and Carboniferous.

*Strophodonta inequistriata*, Conr. At one time identified by Hall with *Orthis interstrialis*, Phil., and now doubtfully separated. *O.* (?) *interstrialis* is a Devonian fossil.

*S. nacrea*, Hall, almost identical with *S. lepis*, Bronn. Devonian.

*Productella*, gen. Species numerous. This genus is essentially a *Producta*, differing from it only in the possession of inconspicuous hinge-teeth and sockets. *Producta* is characteristically a Carboniferous genus.

*Cyrtina Hamiltonensis*, Hall. Closely allied to *C. heteroclita*, Defr., of the Devonian limestone of Europe.

*Athyris spiriferoides*, Eaton. Barely separable from *A. concentrica*, von Buch, an Upper Devonian fossil.

*Atrypa aspera*, Schlot. A common European Devonian form.

*Rhynchonella venustula*, Hall. Identified by Conrad with *R. cuboides*, Sow., one of our common Devonian species; but separated by Hall for some very slight differences.

Cephalopoda.—Several species of *Goniatites* have been found in the Marcellus Shale, the base of the Hamilton group.

Crustacea.—*Phacops rana*, Green. Closely representative of *P. latifrons*, Bronn, of the British and Continental Devonian rocks.

I rely less, however, upon individual species than upon the general facies of the fauna, and the relative proportions of the numbers of the genera and species. In collecting in Western New York, and in reviewing and arranging large series of specimens in the New York State Museum, the forms which were everywhere turning up were *Spirifera, Chonetes, Strophodonta, Atrypa, Cyrtina*, and these of Devonian or even Carboniferous facies. The genus *Productella* is also very significant. Of species the most abundant are *Orthis Vanuxemi, Strophodonta inæquistriata, Spirifera mucronata, Athyris spiriferoides, Atrypa aspera, Cyrtina Hamiltonensis, Heliophyllum Halli*, and *Phacops rana*, all of them represented by identical or closely allied forms in European Devonian or Carboniferous rocks. On the other hand, the Ludlow-like Lamellibranchs are comparatively rare.

The formations underlying the Hamilton must also be taken into account. In the Schoharie Grit, fishes make their first appearance; and, in the later epoch of the Upper Helderberg Limestone, this class is abundantly represented. The types are clearly those of the European Old Red Sandstone. *Macropetalichthys* resembles *Pterichthys*. Forms like *Cephalaspis* and *Holoptychius* also occur. Of plants, *Caulopteris* is found in marine limestones below the Hamilton group in Ohio, and *Lepidodendron* is quoted by Professor Newberry from the same limestone. Generally speaking, the fauna of the Upper Helderberg is intermediate in character between the underlying Lower Helderberg and the overlying Hamilton.

The general testimony of the fossils is clearly in favour of the Devonian age of the Hamilton group, and the exceptional character of the lamellibranchiate fauna is probably to be explained on the supposition that certain causes, biological or otherwise, retarded the migration of the European Ludlow Conchifera to the western seas. Their occurrence in the Hamilton would hardly seem to be sufficient ground for extending the Ludlow upwards so as to include the Hamilton group, as some American geologists are disposed to do.

The formation underlying the Lower Helderberg being the equivalent of the Wenlock, and the formations overlying being clearly correlated with our Devonian, it is fair to conclude that the Lower Helderberg group represents our Ludlow.

A comparison of the Ludlow and Lower Helderberg faunas will not supply us with additional evidence of a very decisive character. Putting on one side the exceptional case of the Conchifera, the Ludlow fauna has no close resemblance to any American formation. Of individual species, we may compare *Phacops* (*Dalmannia*) *longicaudatus* with the much larger *Dalmannia nasuta*, *Rhynchonella Wilsoni* with *R. ventricosa*, and *Strophomena euglypha* with *S. punctulifera*. In the Aymestry Limestone near Broseley, I have also detected *Orthis plano-convexa* of the Lower Helderberg. But of the numerous Cephalopoda of our Lower Ludlow, we have few, or no, representatives in the American area. On the whole, the Lower Helderberg fauna resembles that of the Niagara series of New York more closely than it resembles that of the British Ludlow. The explanation of this is not far to seek. At the close of the Niagara period, the sea shallowed, and salt lakes were formed. But this elevation was followed by a marine epoch, during which the Niagara fauna, driven into adjacent seas by this local upheaval, would return to their old habitat, modified in form to such a degree as we might expect from the interval of time represented by the Salina period. The Lower Helderberg corals and molluscs flourished in the same area as, and on a similar sea-bottom to, the Niagara fauna. But in the British area the conditions were different. During the Ludlow period, the sea was gradually shallowing, so that towards its close the proximity of land is indicated by arenaceous strata and the presence of land-plants, and of fishes, as *Pteraspis*, which probably inhabited fresh-water. A change from a calcareous to a sandy sea-bottom, and from marine to land and fresh-water conditions, would produce a change in the fauna much more rapidly than a mere lapse of time. In the New York area, terrestrial conditions do not set in till the Hamilton period, and, with the coming in of a sediment similar to the Upper Ludlow rock, we have the advent of the Ludlow Lamellibranchs. But where the Hamilton rocks lose their arenaceous character, and pass into calcareous strata, as in Western New York, the Lamellibranchs grow scarce, and the prevailing forms of life are Brachiopoda and Corals of Devonian types.

In correlating rock systems, the work is comparatively easy when the physical conditions under which their faunas flourished were similar. We can compare arenaceous Coal-measures in Europe with arenaceous Coal-measures in America; or a calcareous Wenlock with a calcareous Niagara, and our conclusions are clear and satisfactory. But changes in sediment, and other physical causes, introduce great complexity into the evidence. I do not, however, despair of obtaining true results when, as in the above case, we know the formations above and below the groups which we wish to correlate. Our base-line, a calcareous Wenlock-Niagara Series, is clear. A second level, a calcareous Hamilton-Devonian, is also reasonably distinct. The intermediate zone, the palæontological evidence of which is confused by differences of physical conditions, may fairly be inferred to hold a middle place between Wenlock and Devonian. If, indeed, there is no Devonian, as some have suggested, my argument will require to be remodelled; but it is difficult to study the magnificent series which intervenes between true Silurian and true Carboniferous in New York and Pennsylvania, and to come away with the conclusion that it is a mere base to the Carboniferous.

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## VII.—On the Wealden Entomostraca.

By Prof. T. Rupert Jones, F.R.S., F.G.S.

I SEND as a Supplement to my last communication the subjoined Synoptical view of the species of Wealden Entomostraca, treated of in the March Number of the Geol. Mag., trusting it may prove acceptable to both collectors and systematists.

### Tabulated View of the Purbeck-Wealden Entomostraca of England, as at present known.

#### I.—From the Wealden Beds of the Southern Counties.

1. *Cypridea Valdensis* (Sow. and Fitton).[1] Sowerby's "Min. Conch.," pl. 485, (*Cypris faba*).
2. ——— *Austeni*, Jones. In Fitton's plate; "Trans. Geol. Soc.," ser. 2, vol. iv. pl. 21, fig. 1; Geol. Mag. Dec. II. Vol. V. p. 109, 110, Pl. III. Fig. 8.
3. ——— ? *tuberculata* (Sow.). *Ibid.* p. 104, 105, Pl. III. Figs. 2*b*, *c*.
4. ——— ? *Fittoni* (Mantell). *Ibid.* p. 104, Pl. III. Fig. 2*a*.
5. ——— ? *granulosa* (Sow.). *Ibid.* p. 104, 105, Pl. III. Fig. 4.
6. ——— *spinigera* (Sow.). *Ibid.* Fig. 3.

#### II.—From the Neocomian Freshwater Sands of Shotover, near Oxford.

7. *Candona Phillipsiana*, Jones. Geol. Mag. Dec. II. Vol. V. p. 108, Pl. III. Fig. 3.
8. *Cypridea verrucosa*, Jones. *Ibid.* Fig. 5–7.
9. ——— ———, var. *crassa*, *Ibid.* Fig. 4.
10. ——— *bispinosa*, Jones. *Ibid.* p. 109, Pl. III. Fig. 9–10.
11. ——— *Valdensis* (Sow. and Fitton). *Ibid.* Fig. 11.
12. ——— *Austeni*, Jones. *Ibid.* p. 109, 110, Pl. III. Fig. 8.

#### III.—From the Purbeck Beds of the Subwealden Boring in Sussex.

13. *Cypridea Valdensis* (Sow. and Fitton). Geol. Mag. Dec. II. Vol. V. p. 110, Pl. III. Fig. 13–15.
14. ——— *granulosa* (Dunker). *Ibid.* Fig. 16.

Besides some undetermined specimens. *Ibid.* p. 110.

#### IV.—From the Purbeck Beds of Dorsetshire.

*a.*—Upper Purbeck.

15. *Cypris ? gibbosa*, E. Forbes (near *C. spinigera*, Sow.)
16. ——— ? *tuberculata*, E. F. (near *C. tuberculata*, Sow.)
17. ——— ? *leguminella*, E. F.

*b.*—Middle Purbeck.

18. *Cypris ? striatopunctata*, E. F. (? Fr. A. Römer.)

[1] This is the species generally referred to by Dr. Fitton in his Memoir, but not the form figured by him in his plate.

19. *Cypris ? fasciculata*, E. F.
20. ——— ? *granulata*, E. F. (? *C. granulosa*, Dunker.)

*c.*—Lower Purbeck.

21. *Cypris ? Purbeckensis*, E. F.
22. ——— ? *punctata*, E. F.

These are figured in Sir C. Lyell's "Manual of Geology," see Geol. Mag. *l.c.* p. 105.

Note on the Distribution of the Species.

Nos. 1, 11, and 13. Very common throughout the Wealden and in some Purbeck beds; also in Germany.
2 and 12. Rather rare. Figured by Fitton from some unmentioned locality; Peasemarsh, Surrey; Shotover.
3 and 16. Not uncommon in the Wealden Beds. In the Upper Purbeck.
4. Accompanies *C. tuberculata* in some places.
5. Hastings beds of Sussex; Purbeck beds of South Wilts.
6. Not uncommon in the Wealden beds.
7. Shotover; Obernkirchn, Hanover.
8 and 9. Shotover.
10. Shotover.
14 and 20 ? Subwealden Boring, Sussex; Hanover; Middle Purbeck of Dorset?

*Addenda et Corrigenda.*—At page 101, line 25, *add*: It occurs throughout a bed about 15 feet thick, and is very characteristic of the zone. At p. 101, *add: Estheria tenella* (Jordan), "Monogr. Foss. Estheriæ," 1862, p. 31, etc., has been found abundantly by the Geological Surveyors of Scotland in the Coal-measures near Airdrie; and, in one instance (at Glenmavis Burn), it constitutes a bituminous shale, so thickly are the individuals massed together. From Palace-craig, near Airdrie, where *E. tenella* has lately been obtained, I remember to have seen specimens of a much larger *Estheria*, since lost. At p. 102, line 16 from bottom, *for* Fred. *read* Ferd. At p. 105, line 23, *for* on *read* in. Line 32, *after* figured specimen, *add*: = *Cypridea Austeni*. At p. 109, line 8 from bottom, *add:* Mr. H. Caudell has also found *Cypridea Valdensis* in the Ironstone of Wheatley, two miles S.E. of the other locality.

## NOTICES OF MEMOIRS.

### I.—On the Graptolite Schists of Kongslena in Westrogothia, Sweden.[1] By Dr. G. Linnarsson, Director of the Geological Survey of Sweden.

In the Upper Graptolite schists of Westrogothia two divisions are recognizable—a lower division characterized by *Monogr. lobiferus* (M'Coy) and *Rastrites peregrinus* (Barr.); and a higher division characterized by *Monograpt. priodon* (Bronn) and *Retiolites Geinitzianus* (Barr.). The same divisions, well separated, appear in other parts of the country, and Törnquist has already proposed for them the respective titles of the *Lobiferus Schists* and *Retiolites Schists*.[2]

Among the localities in Westrogothia where the Upper Graptolite Schist is most accessible is Strommen in the parish of Kongslena. These schists, as well as the immediately underlying strata, the Brachiopod Schists and the Trinucleus Schists, are locally cut into by a considerable stream. The Lobiferus Schist is here a black

[1] Abstract of a paper published in the Geologiska Föreningens i Stockholm Förhandlingar, 1877, Nr. 41; Bd. III., Nr. 13.

[2] Törnquist, Ofvers. af K. Vet. Akad. Förhandl., 1875, p. 57.

thinly laminated straight-cleaving schist crowded with Graptolites, which appear as thin shining films of iron-pyrites. It rests upon the Brachiopod Schists, and is surmounted by a grey flag-like rock, which has not hitherto yielded fossils, but possibly represents the *Retiolites Schist.*

At the time the author described the sequence of the Silurian rocks of Westrogothia some years ago,[1] a very small number of species only had been detected at Kongslena. In the summer of 1876, in a fresh visit to this locality, he was fortunately able to add greatly to his former discoveries. In specific richness the Lobiferus Schist at this spot now exceeds that of all other known Swedish localities. The description of several forms which appear to be new is best deferred till more and better material has been obtained; and the state of preservation of others which are already named does not admit of their certain identification. The following list is therefore far from complete.

Graptolites from the *Lobiferus Schist* of Kongslena.

| | |
|---|---|
| *Monograptus lobiferus*, M'Coy. | *Rastrites peregrinus*, Barr. |
| ——— *sagittarius*, His. | *Diplograpt. palmeus*, Barr. |
| ——— *Sandersoni*, Lapw. | ——— *cfr. modestus*, Lapw. |
| ——— *Sedgwicki*, Portlk. | ——— *cometa*, Geinitz. |
| ——— *spiralis*, Geinitz. | ——— *tamariscus*, Nich. |
| ——— *triangulatus*, Harkn. | *Climacogr. rectangularis*, M'Coy. |

Schists with a similar fauna occur not only in Westrogothia, but in many other districts in Sweden, as in Dalarne and Scania.

In the island of Bornholm it is probable that the *Lobiferus Schist* is paralleled by the lower portion of the graptolitiferous schists which are denominated by Johnstrup[2] the Uppermost Graptolite Schists. In Norway and the Russian Baltic Provinces no precise equivalents of the Lobiferus Schist are known. It is not improbable that beds of the same age may exist there, but if so, they have so wholly different a facies that it is impossible to compare them. Very different however is their correlation with the Silurian rocks of Britain. If we examine a list of the fossils of the latter, we recognize almost all the above-mentioned Graptolites. Notwithstanding this, however, it was formerly impossible to parallel the Lobiferus Schist with any special portion of the English succession as arranged by Murchison. This was mainly owing to the circumstance that these Graptolites had not been discovered in the districts whence Murchison drew the types for his Silurian system. In other parts of the country, as in the Coniston and Moffat Groups of the Lake District and the South of Scotland, they have long been known; and it has already been shown by the author[3] that these include equivalents of the Upper Graptolite Schists. But respecting these, and the other British graptolitic deposits relatively older, we have always had very

[1] Linnarsson, Om Vestergötlands Cambriska och Siluriska aflagringar, K. Vet. Akad. Hand., Bd. 8, Nr. 2, 1869.

[2] Johnstrup, Oversigt over palæozoiske Dannelser paa Bornholm, Forh. v. d. Skandinav. Naturf. 11te. sid 307.

[3] See, for example, Linnarsson, "On the Vertical Range of Graptolites in Sweden," Geol. Mag. Dec. II. Vol. III. 1876.

incorrect ideas. In the Catalogue of the Silurian Fossils given by Murchison (Siluria, 4th edition), several of the above-mentioned fossils are included, such as *Monogr. lobiferus* (=*Becki*) and *M. sagittarius, Rastrites peregrinus* and *Diplogr. cometa*, but all are placed under the head of the Llandeilo formation. In his description of the Silurian succession in Westrogothia, the author was therefore compelled to parallel the Upper Graptolite Schists with a part of Murchison's Llandeilo, though with an intimation that Murchison's arrangement must somehow have been erroneous, in thus assigning them a systematic position inferior to the Chasmops Limestone and Trinucleus Schist, which of all Swedish beds most nearly resemble the Caradoc, and actually *underlie* these Upper Graptolite Schists. In the list of British Graptolites given by Nicholson in his Monograph[1] he includes many of the Graptolites of the Lobiferus Schist. The majority, such as *M. lobiferus* and *sagittarius, Ras. peregrinus* and *Diplogr. tamariscus*, are said to occur both in the Upper Llandeilo and in the Caradoc. *Diplo. cometa* is given from the Upper Llandeilo only. To judge from this, the Lobiferus Schist ought best to be compared with the transition beds between the Llandeilo and Caradoc. Even this, however, conflicts with the above-mentioned fact that the Lobiferus Schist reposes upon strata, the fauna of which most nearly corresponds to that of the Caradoc.

For the first time, through Lapworth's accurate researches in the South of Scotland, has the Graptolite-bearing series in Great Britain been developed in a satisfactory manner. He divides the richly graptolitic Moffat group into three parts—the Lower or Glenkiln Shales, the Middle or Hartfell Shales, and the Upper or Birkhill Shales —of the fossils of which he gives a catalogue.[2] According to this, we find that the Upper Moffat (Birkhill Shales) completely parallelizes with the Lobiferus Schist. Nearly all the Graptolites we find at Kongslena are found in the Upper Moffat, and none of them are mentioned from either of the underlying divisions. The Middle Moffat, again, is the equivalent in time of the Schists with *Dicranograptus Clingani* and *Diplogr. foliaceus*, which occur in Scania, as at Fogelsang, Josterup, and Jerrestad. This close concordance with the Swedish succession shows that we may, without doubt, look upon Lapworth's classification of the Scottish series as being correct. As regards the systematic relations of the Scottish rocks to the typical English series again, Lapworth holds totally different views from those of preceding authors. In the Moffat group, for example (which Murchison and Nicholson—the latter at least in 1872—regard wholly as Llandeilo), Lapworth considers that the Lower Moffat only belongs to the Llandeilo, the Middle Moffat to the Caradoc; while of the Upper Moffat it is said that it "seems to belong almost wholly to the Lower Llandovery." This last-mentioned comparison at least does not conflict with the Swedish relations. That is to say, in several of the rock divisions, which

[1] A Monograph of the British Graptolitida, Edin. & Lond. 1872, p. 97, et seq.
[2] A Catalogue of the Western Scottish Fossils, Glasgow, 1876, p. 97, et seq.

precede the Lobiferus Schist, the fauna has already appeared, which is most nearly to be compared with that of the Caradoc group.

In the North of England again we meet with the Graptolites of the Lobiferus Schists in that group of shaly strata called the Coniston Mudstones.[1] According to the lists of their fossils given by Harkness and Nicholson, they include a Trilobite fauna having a thoroughly Lower Silurian aspect, and which can best be compared with that of the Trinucleus Schiefer. Till this abnormal relationship has been confirmed, the author is of opinion that we ought to be allowed to believe that some mistake has been committed.

Several of the fossils of the Lobiferus Schist, such as *M. lobiferus*, M'Coy, *M. spiralis, Rastrites peregrinus* and *Diplograpt. palmeus*, are found also in Bohemia, partly in Barrande's Etage Ee1, and partly in the Colonies in his Etage D.[2] On both stratigraphical and palæontological evidences, the author had already paralleled the Lobiferus Schists, in common with the Upper Graptolite Schists, with the Etage Ee1. Törnquist, on the contrary, has suggested that the Upper Graptolite Schists are rather contemporaneous with the Colonies.[3] This last view is chiefly founded upon the supposed English succession; but now, since this has been more accurately determined, the facts give force, on the other hand, to the author's opinion. It was formerly supposed that the fauna which characterized the Swedish Upper Graptolite Schists belonged to the Llandeilo and Caradoc. It is now proved that they belong to the Middle and Upper Silurian strata. As regards the equivalents of the Lobiferus Schist—the Birkhill Shales and the Coniston Mudstones—the former are believed by Lapworth to belong to the Lower Llandovery; the latter by Harkness and Nicholson to the Uppermost Bala or Lowest Llandovery.

The Coniston Flags, which in their strata and fossils may be compared with the Retiolites Schists, are now regarded by English authors as an Upper Silurian formation. In England, therefore, as well as in Sweden and Bohemia, these special Graptolite faunas thus stand in near relation to the Upper Silurian formations. Their appearance in *true* Lower Silurian formations is, on the contrary, peculiar to Bohemia. The Leptena Limestone, which overlies the Upper Graptolite Schists, can scarcely be mentioned as true Lower Silurian; while the Brachiopod Schist, which underlies the Lobiferus Schist, has already a far greater Upper Silurian aspect than even the very highest strata of Barrande's Etage D. These last-mentioned beds agree nearest with the lower part of the Trinucleus Schists of Sweden. Naturally, perfect synchronism between the Swedish Upper Graptolite Schists and the Bohemian Etage Ee1, can hardly be said to be actually demonstrated. They are, however, at any rate,

[1] See, for example, the list given by Harkness and Nicholson, Quart. Journ. Geol. Soc., London, vol. xxxiii. 1877, p. 473. The Coniston Mudstones are not, as asserted by these authors, equivalent to the whole of the Swedish Upper Graptolite Schists. The Retiolites Schists are clearly older and are related to the Coniston Flags.

[2] *Vide* Barrande, Defense des Colonies, 1870, vol. iv. p. 125.

[3] Törnquist, Om Siljanstraktens paleozoiskas formationsled, Öfvers. af K. Vet. Akad. Förhandl., 1874, Nr. 4, p. 24.

*homotaxeous*, and for the present nothing is known which would lead us to suppose that one was older than the other.

It has long been the general opinion that the Graptolites which characterize Barrande's Colonies and his Etage Ee1, had originally their home in the N. of Europe, and that from thence they made excursions into the Bohemian basin. In their earlier migrations they could not find complete footing there, and consequently formed a colony which soon died out. Later, viz. at the time of the formation of Barrande's Etage Ee1, they established themselves in permanent occupation of the Bohemian basin.

Formerly, when it was thought that the Graptolites of the Upper Graptolite Schists were co-existent with the Trilobites of the Trinucleus Schists, and that their equivalent English Graptolite-bearing beds belonged to the Llandeilo and Caradoc, such a view was very natural. Now, however, the better insight we have attained of the English and Swedish succession has robbed it of all its force. There is now no reason to believe that the Graptolites which inhabited Barrande's Colonies had emigrated from the ocean of the north. Where they came from is, at least for the present, impossible to determine; but probably the Bohemian Colonies are older than all the Swedish and English beds in which the same fauna is found. Instead of the emigration having taken place as believed hitherto, if we may judge from the facts already obtained, it would rather have taken place in the opposite direction.—Carl Faye.

### II.—Prof. J. Woldrich—On Pleistocene Canidæ.

(Imper. Acad. Vienna, Meeting April 4, 1878.)

The remains found in the Loess of Lower Austria and in the Caves of Franconia, Württemberg, and Moravia prove the family of *Canidæ* to have been represented in Europe during the "Diluvial" (Pleistocene) period, in its Lupine or Wolf type by the genera—*Cyon* (2 species), *Lycorus* (1 sp.), *Canis* (1 sp.), *Lupus* (4 sp.); and in its Vulpine or Fox type by the genera — *Vulpes* (4 sp.) and *Leucocyon* (1 sp.): altogether 13 species. A nearly complete skeleton of *Lupus Suessi*, now in the University Museum at Vienna, was found some years ago in the Loess of Nussdorf, N.W. of Vienna, overlying the plastic clay of Hernals. This species was characterized by a powerful and not very large head, a very strong neck, and a vigorous muscular system. It was more robust than *Lupus spelæus;* and intermediate in size between that species and the existing Wolf. The structure of its extremities shows that it was fleet enough to pursue even the larger Herbivores and strong enough to overpower them.—Count Marschall.

## REVIEWS.

### I.—Revue de Géologie pour les Années 1875 et 1876. Par M. Delesse et M. De Lapparent. (Paris, 1878.)

THE constantly increasing numbers of geological papers published in the various Journals, Proceedings, and Memoirs of Societies, renders it difficult, at the present time, for the student of the science to become readily acquainted with the literature of the subject. Special works, therefore, giving a periodical *résumé* of the different widely scattered publications are not only a great boon, but attest a self-denying and laborious energy on the part of the respective editors. In this country we have the valuable Geological Record, edited by Mr. Whitaker; in Switzerland the Revue géologique Suisse, compiled by M. E. Favre; and in France the Revue de géologie, under the able direction of MM. Delesse and De Lapparent, and which has now attained its fourteenth year. The present volume (1878), compiled with the same care and arranged in the same manner as the previous ones, comprises the various papers on geological and the allied sciences printed during the years 1875 and 1876, besides which are inserted many useful private communications forwarded to the editors by different geologists, and also (as in previous volumes) the analyses of rocks which have been undertaken in private laboratories, or in those of the Ecole des Mines or the Ecole des Ponts et Chaussées. The classification of the subjects is adopted from the Manual of Geology, by Dana and arranged under the five chief divisions of Physiographical, Lithological, Historical, Geographical, and Dynamical Geology, special attention being given by M. Delesse to the researches on rocks and their metamorphism.

The editors have noticed the works of more than 400 authors, and have given a concise account of their contents, noticing to a greater extent those not published in France.—J.M.

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II.—Victorian Organic Remains.—Prodromus of the Palæontology of Victoria. Decade V. By Prof. F. M'Coy, F.G.S., etc. (Melbourne, 1877.)

The figures and descriptions of the new or more characteristic Victorian organic remains of each formation are continued by Prof. M'Coy in this fifth decade, which is, therefore, an assistance to the field geologist in determining the approximate geological ages of the various formations he may meet with. The present number is of equal importance with the preceding ones, and contains illustrations of fossils of much interest both to the Colonial and European palæontologist, for some of the species noticed of Upper Silurian mollusca are identical with well-known abundant and characteristic forms of Europe and North America, whilst others are representative. So also with some Eocene forms, it is shown that the most careful comparison is necessary to distinguish between species of *Cardium* from the Tertiary strata of Australia and our own country. The contents of this number are various; the first two plates illustrate new extinct species of Eared Seal (*Arctocephalus Williamsi*) from the Pliocene strata of Queenscliff, and nearly related to the living genera of the Southern Seas; the third, fourth, fifth, and ninth plates are devoted to illustrations of some characteristic forms of Tertiary Mollusca, as *Waldheimia, Cardium, Spondylus,* and *Cypræa;* the sixth and seventh plates contain many figures of Upper Silurian Brachiopoda. The next plate illustrates a new spheroidal Tertiary species of Sponge, with the long slender siliceous spicules of the genus *Tethya*, and a remarkable extinct gigantic species of Sea-pen, or *Graphularia*, allied to that found in the London Clay of England, and closely allied to the living form (*Sarcoptilon*) in Hobson's Bay. Under this head, Prof. M'Coy suggests whether the supposed Mesozoic genus *Belemnites* may have been a different interpretation of the same object. The last plate gives further illustrations to those in preceding decades of the Graptolites of the gold-field slates, one a new type, and the others identical with a species (*G. Headi*, Hall) found in similar slates in Canada.—J.M.

## REPORTS AND PROCEEDINGS.

Geological Society of London.—April 17, 1878.—Henry Clifton Sorby, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Geological Results of the Polar Expedition under Admiral Sir George Nares, F.R.S." By Capt. H. W. Feilden, R.A., F.G.S., and C. E. De Rance, Esq., F.G.S.

The authors describe the Laurentian gneiss that occupies so large a tract in Canada as extending into the Polar area, and alike underlying the older Palæozoic rocks of the Parry Archipelago, the Cretaceous and Tertiary plant-bearing beds of Disco Island, and the Oolites and Lias of East Greenland and Spitzbergen. Newer than the Laurentian, but older than the fossiliferous rocks of Upper Silurian age, are the Cape-Rawson beds, forming the coast-line between Scoresby Bay and Cape Cresswell, in lat. 82° 40′; these strata are unfossiliferous slates and grit dipping at very high angles.

From the fact that Sir John Richardson found these ancient rocks in the Hudson's Bay territory to be directly overlain by limestones, containing corals of the Upper Silurian Niagara and Onondaga group, Sir Roderick Murchison inferred that the Polar area was dry land during the whole of the interval of time occupied by the deposition of strata elsewhere between the Laurentian and the Upper Silurian; and the examination by Mr. Salter, Dr. Haughton, and others of the specimens brought from the Parry Islands have hitherto been considered to support this view. The specimens of rocks and fossils, more than 2,000 in number, brought by the late expedition from Grinnell and Hall Lands, have made known to us, with absolute certainty, the occurrence of Lower Silurian species in rocks underlying the Upper Silurian; and as several of these Lower Silurian forms have been noted from the Arctic Archipelago, there can be little doubt that the Lower Silurians are there present also. The extensive areas of dolomite of a creamy colour discovered by M'Clintock around the magnetic pole, on the western side of Boothia, in King William's Island, and in Prince of Wales Land, abounding in fossils, described by Dr. Haughton, probably represent the whole of the Silurian era and possibly a portion of the Devonian.

The bases of the Silurians are seen in North Somerset, and consist of finely stratified red sandstone and slate, resting directly on the

Laurentian gneiss, resembling that found at Cape Bunny and in the cliffs between Whale and Wolstenholme Sounds. Above these sandstones occur ferruginous limestones, with quartz grains, and still higher in the series the cream-coloured limestones come in. The Silurians occupy Prince Albert Land, the central and western portion of North Devon, and the whole of Cornwallis Island. The Carboniferous Limestone was discovered, rising to a height of 2,000 feet, on the extreme north coast of Grinnell Land, in Feilden and Parry Peninsulas, and contains many species of fossils in common with the rocks of the same age in Spitzbergen and the Parry Archipelago, being probably continuously connected with the limestone of that area, by way of the United States range of mountains. The coal-bearing beds that underlie the Carboniferous Limestones of Melville Island are absent in Grinnell Land, but they are represented by true marine Devonians, established in the Polar area for the first time, through the determination of the fossils, by Mr. Etheridge. In America a vast area is covered by Cretaceous rocks. The lowest division, the Dakota group, contains lignite seams and numerous plant-remains indicating a temperate flora; overlying the Cretaceous series are various Tertiary beds, each characterized by a special flora, the oldest containing subtropical and tropical forms, such as various palms of Eocene type. In the overlying Miocene beds the character of the plants indicates a more temperate climate, and many of the species occur in the Miocene beds of Disco Island, in West Greenland, and a few of them in beds associated with the 30-feet coal-seam discovered at Lady Franklin Sound by the late expedition. The warmer Eocene flora is entirely absent in the Arctic area, but the Dakota beds are represented by the "Atane strata" of West Greenland, in which the leaves of dicotyledonous plants first appear. Beneath it, in Greenland, is an older series of Cretaceous plant-bearing beds, indicating a somewhat warmer climate, resembling that experienced in Egypt and the Canary Islands at the present time. In the later Miocene beds of Greenland, Spitzbergen, and the newly discovered beds of Lady Franklin Sound, the plants belong to climatal conditions 30° warmer than at present, the most northern localities marking the coldest conditions. The common fir (*Pinus abies*) was discovered in the Grinnell Land Miocene, as well as the birch, poplar, and other trees, which doubtless extended across the polar area to Spitzbergen, where they also occur.

At the present time the coasts of Grinnell Land and Greenland are steadily rising from the sea, beds of glacio-marine origin, with shells of the same species as are now living in Kennedy Channel, extending up the hill-sides and valley slopes to a height of 1000 ft., and reaching a thickness of from 200 to 300 ft. These deposits, which have much in common with the "boulder-clays" of English geologists, are formed by the deposition of mud and sand carried down by summer torrents and discharged into fiords and arms of the sea, covered with stone- and gravel-laden floes, which, melted by the heated and turbid waters, precipitate their freight on the mud below. As the land steadily rises these mud-beds are elevated above the sea.

The coast is fringed with the ice-foot, forming a flat terrace 50 to 100 yards in breadth, stretching from the base of the cliffs to the sea-margin. This wall of ice is not made up of frozen sea-water, but of the accumulated autumn snowfall, which, drifting to the beach, is converted into ice where it meets the sea-water which splashes over it.

2. "On the Palæontological Results of the recent Polar Expedition under Admiral Sir George Nares, K.C.B., F.R.S." By Capt. H. W. Feilden, R.A., F.G.S., and Robert Etheridge, Esq., F.R.S., F.G.S.

In this communication the authors brought before the Society the palæontological results and details of the collection made by the naturalists and other officers of the late expedition to the Arctic Circle under Admiral Sir G. Nares. The purpose of the paper was to record the presence of Silurian and Carboniferous fossils in the highest latitude yet reached, 82° 45′ N. Of the former group 60 species have been determined, ranging from the Lower to the Upper Silurian, both Llandeilo and Wenlock types being present and numerous, notably in the class Heteropoda, two species of the genus *Maclurea* and *Bellerophon*, with *Strophodonta* and *Raphistoma*, etc., also the genus *Receptaculites.* Upper Silurian species of Actinozoa belonging to *Halysites, Favosites, Heliolites, Favistella, Zaphrentis, Amplexus, Cyathophyllum*, and *Arachnophyllum* were noticed, and correlated with British forms when possible; but, on the whole, the facies of the Cœlenterata is American rather than European. Amongst the Crustacea five genera were noticed—*Bronteus, Calymene, Encrinurus*, and *Proëtus*, all Upper Silurian; and the genus *Asaphus*, associated with *Maclurea*, of Lower Silurian age. Ten species of Brachiopoda belonging to the genera *Pentamerus, Rhynchonella, Chonetes, Atrypa, Strophomena*, have been determined.

Collections were made from twenty localities, ranging from lat. 79° 34′ to 82° 40′ N., notably the highest at Cape Joseph Henry, where Capt. Feilden obtained a numerous Carboniferous-Limestone fauna, numbering about thirty species, chiefly Brachiopoda and Polyzoa, all determined species, and American in character rather than British. Mr. Etheridge believed he had determined, through certain forms of Brachiopoda, the presence in a ravine at Dana Bay of the Devonian rock below the Carboniferous Limestone south of Cape Joseph Henry and Feilden Isthmus, the want of plant-remains preventing any correlation with the Ursa stage of Heer. It cannot now be doubted that an extensive Silurian fauna extends to, and is present from lat. 79° to lat. 82° N., illustrating both the lower and upper divisions of this group of rocks, especially the equivalents of our Wenlock series. Again, north of these there sets in a clearly defined Carboniferous-Limestone fauna, reaching the extremity of the highest latitude we know, and probably striking away beneath the Polar sea to Spitzbergen, where the same species have been described by Toula. The authors, through certain fossils, then endeavoured to show that on the whole the facies of the Polar palæozoic fauna was more nearly allied to that of America than to that of Europe, and thus must be correlated with it, although it was shown that a large number of species are common to the two areas, especially the British Islands. The absence of Lamellibranchiata in rocks older than the Tertiary was noticed as having special interest in the physical history of the Polar seas in Palæozoic and Mesozoic times. None have ever been detected in these rocks. The authors stated that they had sought also for evidence of Trias and Permian fossils in this and other collections made, but there appeared to be none. They also discussed the question of the deposition and extension of the Lias as represented at Eglinton Island and Spitzbergen. The authors furnished a Table showing the distribution of all the species collected by the expedition from twenty localities.

## CORRESPONDENCE.

### SAND-WORN PEBBLES IN THE WEALDEN OF SUSSEX.

SIR, — Being at Cuckfield lately, I obtained, by the kindness of Mr. Henry Willett, F.G.S., some of the large pebbles and subangular pieces of quartz, quartzite, and lydite from the conglomerate, or pebbly and gritty bone-bed, of the "Upper Tunbridge-Wells Sandstone" in the quarry at Whiteman's Green, near the town. A glaze-like polish in parts of some of these stones attracted my attention; and, on looking at it with the microscope, I discerned the delicate parallel striæ which *blown sand* produces in polishing rocks and stones exposed to its action.

One of these partially glazed stones from the Cuckfield grit has also the *triangular shape* produced by the persistent action of blown sand, and must have been long exposed to such influence on the strand of the old Neocomian lake or estuary, before it was finally imbedded among the grit and rolled bones. Notices of the conglomerate referred to above are given in Mantell's "Geology of the South-East of England," 1833, p. 209, etc., and in the "Memoirs Geol. Survey" (Topley's Weald), 1875, p. 93, and p. 187, *note*.

YORKTOWN, *April* 10, 1878. T. RUPERT JONES.

### THE PRESERVATION OF DEPOSITS OF INCOHERENT MATERIALS UNDER TILL OR BOULDER-CLAY.

SIR,—Mr. S. V. Wood, in his "Reply" (GEOL. MAG. Dec. II. Vol. V. p. 187), complains that I have not put the questions at issue between us so incisively as he could have wished. I am sorry to have so far disappointed my opponent, but it was not my intention to controvert all his theoretical views. If he will look at the title of my short paper, he will see that I confine myself to one point, namely, the preservation of interglacial deposits. Mr. Wood has so frequently denied the possibility of interglacial beds having been overflowed by glacier-ice, and so confidently asserted that my views were self-contradictory, that I thought it worth while to point out that his principal, indeed his only, argument was based upon what he himself tacitly admits is merely a preconceived notion. I am glad to find, however, that in other respects his views approximate to mine more nearly than he seems to be aware. Thus, he tells us first, that he does not deny "that ice erodes more in some places than in others;" secondly, that he believes "some moraine accumulates below ice;" and thirdly, that it may to some extent be true that ice does override incoherent deposits without entirely obliterating them. But he instances the section exposed in the North Suffolk Cliff, where Till rests for a long distance upon a comparatively undisturbed surface of sand, as proving that the former deposit has been laid down in the sea, and as demonstrating the physical impossibility of its having been accumulated under ice. Here, again, Mr. Wood's argument is based as before upon the same preconceived notion. He quietly ignores all the *positive* evidence which has been adduced in proof of the subglacier origin and accumulation of the chalky till of Suffolk, and brings forward not one single jot or tittle of positive evidence in favour of his own view. Yet, surely, if the Till in question were a marine formation, there should be no lack of such evidence. If the chalky boulder-clay were laid down upon the sea-bottom, a wide area in the south-east of England must have been submerged, and that for a considerable time. Where, then, I would ask, are the bedded gravel, sand, and clay—the raised beaches and so forth—with marine organisms, which we might reasonably expect to meet with? Where, in short, are the beds equivalent in origin to the shelly brick-clays, etc., of Scotland, Scandinavia, and Canada? Can it be that the sea-bottom of glacial times, in the East Anglian district, was dredged with clay and peppered with stones and boulders at so rapid a rate as to render marine life impossible!

I quite agree with Professor Young that the question of the origin of Till necessarily precedes that of the preservation of inter-glacial deposits, and I have before now expressed myself to that effect. In the short paper which has called forth his remarks, the subject of the origin of Till was not taken up for the simple reason that I had already discussed that question at sufficient length elsewhere. I still think that the theory of the subglacier origin and accumulation of Till meets every difficulty, and offers a satisfactory explanation of all the phenomena, and I can only regret that my friend is of a different opinion. The view which he inclines to favour has at the first blush a plausible appearance, but it will not stand a closer examination. I was myself disposed at one time to think that the Till might have been deposited in the sea in front of an ice-sheet. But the explanation completely failed when I came to put it to the proof. The objections to it are well-nigh legion, but only one of these need be mentioned here—not because it is the most cogent, but because it can be stated in very few words. Wide-spread and thick deposits of Till occur on the lee-side of the Sidlaws, the Ochils, and other hill-areas in Central Scotland, and many of the included boulders prove that the Till in question has been forced up and over these hills. Now, if the hills were submerged at the time they received their coverings of Till, where, let me ask, was the ice-sheet?

PERTH, *April 20th*, 1878. JAMES GEIKIE.

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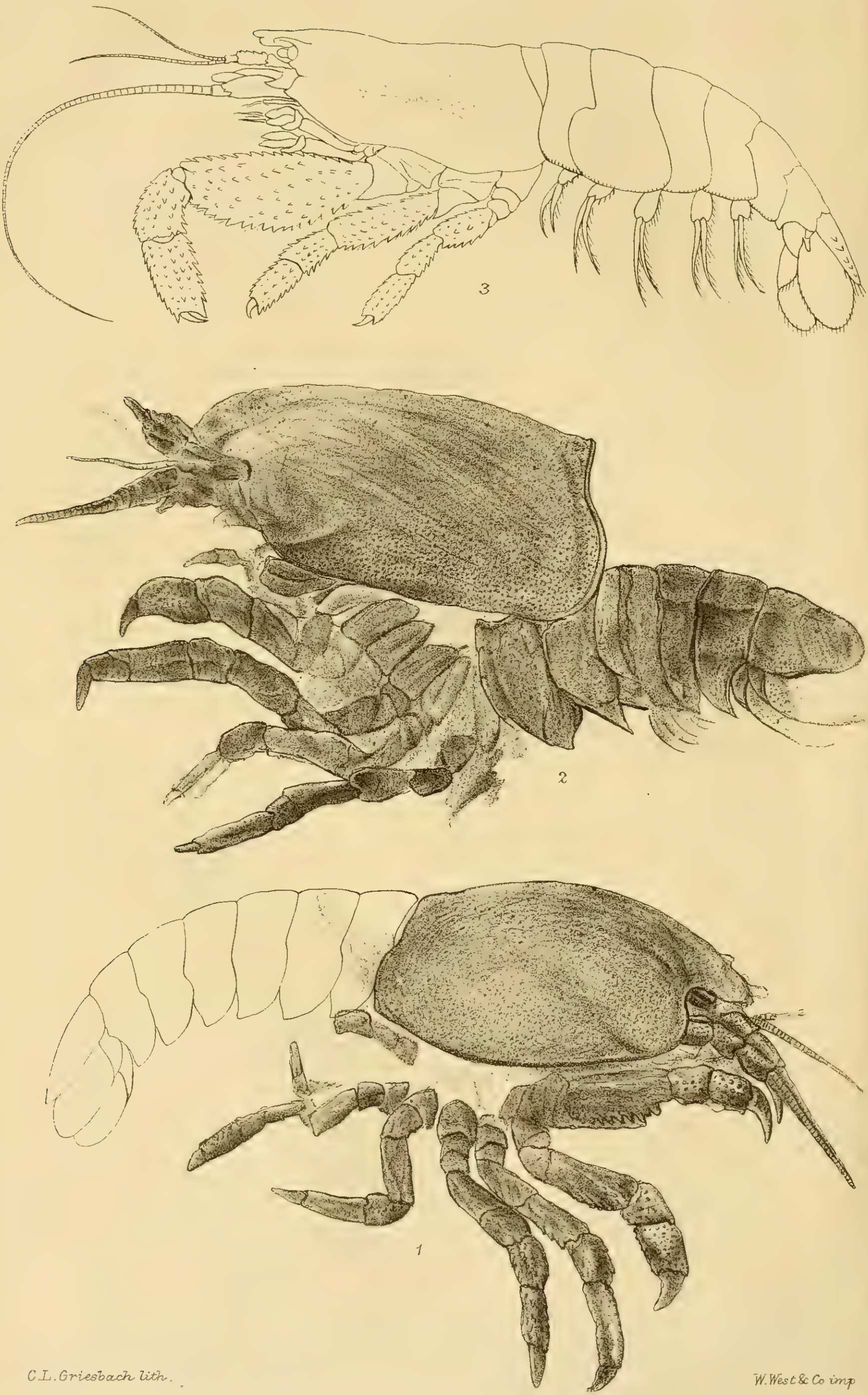
*Erratum.*—From Mr. A. Champernowne, F.G.S. In Plate VI. Fig. 2 (of the May Number), the arched dotted line over the group 3 is an error, and should be omitted.




C. L. Griesbach lith.

W. West & Co imp.

Figs 1 & 2. Præatya scabrosa, H. Woodw.
*Lower Lias, Barrow-on-Soar.*
Fig. 3. Atya scabra, Leach (*Recent*) N. America.

THE
# GEOLOGICAL MAGAZINE.
NEW SERIES. DECADE II. VOL. V.

No. VII.—JULY, 1878.

## ORIGINAL ARTICLES.

### I.—On a New and Undescribed Macrouran Decapod Crustacean, from the Lower Lias, Barrow-on-Soar, Leicestershire, etc.

By Henry Woodward, LL.D., F.R.S., F.G.S.;
of the British Museum.

(PLATE VII.)

In my third Report "on the structure and classification of the fossil Crustacea," presented to the Geological Section of the British Association, at their Meeting in Dundee,[1] 1867, I stated that a new Crustacean had been obtained, in 1858, by Sir Philip Grey-Egerton, Bart., M.P., F.R.S., from the Lower Lias of Barrow-on-Soar, Leicestershire, by whose kindness it is now preserved in the British Museum: and also that another specimen, from the Lower Lias of Somersetshire, belonging evidently to the same species, had subsequently been found by Mr. Charles Moore, F.G.S., at Bath. The specimen from Barrow-on-Soar (the impression and counterpart of which is contained in two blocks of Blue Lias Stone) exhibits on the surface of the slabs, the entire carapace, the eye, antennæ, the five ambulatory thoracic feet; but in this specimen the abdominal somites and caudal appendages are entirely wanting.[2] (See Pl. VII. Fig. 1.)

Mr. Moore's specimen, though rather less well preserved, exhibits the carapace with the antennæ; the walking limbs are displaced and expose the thoracic apodemata to which the branchiæ and the coxal joint of each limb were attached. The six abdominal somites are also seen, but the caudal plates are only very imperfectly preserved. (See Plate VII. Fig. 2.)

The carapace of this Crustacean evidently was extremely thin and much less chitinous than in the genera *Ager* and *Penæus;* it was therefore more easily destroyed or distorted. In Fig. 1, the crumpled and wrinkled appearance of the carapace is well shown. In Fig. 2, the test is less well preserved, but near the posterior border there is evidence to show that the surface was finely granulated (not punctated as represented by the artist in the Plate). The dorsal

[1] See British Association Reports for 1867 (1868), p. 44.

[2] The abdominal somites have been added by the artist in outline to Fig. 1, Pl. VII. merely to indicate their normal position; they are wanting in this specimen, and although present in Mr. Moore's Crustacean from Bath (Fig. 2. Pl. VII.), they are displaced.

line of the carapace, as seen in profile in our specimens, was much arched, and the anterior portion bends down to terminate in a short and blunt rostrum.

The orbital fossa forms a deep hollow on either side of the blunt rostrum giving insertion to the eye-peduncles; the bases of the antennæ take their rise from the outer border of the orbits.

The carapace is marked at its posterior margin by a double line or raised border, and is somewhat roundly inflected mesially, to give insertion to the abdominal somites; but it again expands roundly on the postero-lateral border over the branchial region.

None of the usual divisional lines or prominences, marking the regions of the carapace, are visible on this Crustacean, and, save a small marginal ridge on the hepatic border, near the orbital fossa, the carapace is otherwise quite plain.

Length of carapace 50 mm., depth from dorsal line 25 mm.

The antennules have slender multiarticulate flagella 15 mm. in length. The antennæ have three robust and very rugose basal joints, 15 mm. long, succeeded by a stout but tapering many-jointed flagellum nearly 25 mm. in length, reminding us of the stiff outer antennæ of *Palinurus.*

The thoracic limbs are stout and rugose, all their extremities are monodactylous. The first pair is the most robust, the second is nearly equal in size to the first; the third and fourth pairs are more slender and nearly as long; the fifth pair is much the smallest.

I subjoin the measurement of the five thoracic limbs in millimètres.

| Limbs of thorax | I. | II. | III. | IV. | V. |
|---|---|---|---|---|---|
| 1st joint or Coxa | 3 ? | 3 | 3 | 3 | 2 |
| 2nd „ Basos | 4 ? | 4 | 4 | 4 | 2 |
| 3rd „ Ischium | 7 | 6 | 7 | 4 | 4 |
| 4th „ Meros | 13 | 12 | 9 | 8 | 7 |
| 5th „ Carpus | 6 | 5 | 5 | 5 | 5 |
| 6th „ Propodos | 6 | 6 | 8 | 9 | 7 |
| 7th „ Dactylus | 7 | 6 | 5 | 5 | 5 |
| Total length | 46 | 42 | 41 | 38 | 32 |

The figures of the fossil drawn in the Plate do not sufficiently show the rugosity of the limbs, which is a strongly-marked character in the fossil. The abdominal somites are preserved more or less perfectly in Mr. Charles Moore's specimen (Fig. 2). Their breadth is about 7 mm. each, and extreme depth of profile of segment 19 mm.; the epimeral border of the segments is lanceolate. The segments were finely granulated on their margins. The caudal plates appear to have been broadly rounded in outline, but they are too imperfect to describe minutely.

Total length of abdomen 55 mm.

In most of our common living Macroura, the first and second pairs of thoracic appendages resemble the last pair of the cephalic series, being maxillipeds, or mouth-organs. The third pair are usually the largest of the series, and are mostly chelate (serving as hands), the four remaining pairs being commonly employed as the ambulatory legs.

In the fossil before us neither the third pair, nor the four pairs of limbs succeeding it, are chelate, all the five pairs of legs being monodactylous, as in *Palinurus*, *Scyllarus*, and *Thenus*: but in this division the carapace and the abdominal segments are not arched, but expanded laterally; whilst this Lias Crustacean, like the *Astacidæ*, *Palæmonidæ*, etc., has the carapace compressed laterally, and the segments of the abdomen are not flattened, but are well arched. The antennules are not like those of *Palinurus*, which have a few long articuli, but are multiarticulate like those of the *Astacidæ* and *Palæmonidæ*.

From a careful comparison, made in 1867, of its general characters, I was led to consider the fossil before us as probably most near to the recent genus *Atya* of Leach, from South[1] America, and I then proposed to name it *Præatya scabrosa*, but in all the recent species of the genus *Atya* the third and fourth pairs of thoracic appendages are modified so as to subserve, like the first and second pairs, rather the office of maxillipeds or mouth-organs than of feet; the fifth, sixth, and seventh pairs alone remaining as simple monodactylous ambulatory legs. Whether this modification of the third and fourth pairs of thoracic appendages in the genus *Atya* has taken place since Liassic times, and so the fossil form be really ancestrally related to that modern crustacean, can only be a matter of conjecture, but bearing in mind this important difference in the modification of the thoracic limbs, they have nevertheless still many points of resemblance. I have therefore retained the original name *Præatya* (conferred upon it in 1867), and by that appellation I now beg leave to introduce it to palæontologists and especially to those who are interested in Liassic fossils.

### Explanation of Plate VII.

Fig. 1. *Præatya scabrosa*, H. Woodw., Lower Lias, Barrow-on-Soar (drawn nat. size). The original specimen in the British Museum.

„ 2. *Præatya scabrosa*, H. Woodw., Lower Lias, Bath. The original specimen in the Collection of Charles Moore, Esq., F.G.S., of Bath.

„ 3. Outline of *Atya scabra*, Leach (recent), South America.

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## II.—On the Possibility of Changes in the Latitudes of Places on the Earth's Surface; being an Appeal to Physicists.

By O. Fisher, Clk., M.A., F.G.S.

MR. HILL'S paper in the June Number of the Magazine has incited me to recur to the great question of the possibility of changes in the earth's axis of rotation within itself. Mr. Hill is well known to be an accomplished geologist; but he writes as if he were simply a physicist, without sympathies for the difficulties of his brethren of the hammer. Yet we feel certain that such is not the case. We know that he has studied in the field the tremendous movements which the strata have undergone, being often compressed into a small part of their original length: that he has appreciated the almost ubiquitous presence, either in past or present time, of volcanic activity: that he must feel how unsatisfactory all explana-

[1] Incorrectly marked as N. America on the Plate.

tions short of a change in latitude are to account for the flora of a warm climate within the arctic circle. We therefore appeal to him, and to others similarly qualified, to look at this subject from both sides.

Dr. John Evans, in a paper which he read before the Royal Society in 1866,[1] suggested a cause why, in his opinion, a mountainous region, newly upheaved above the general surface of the earth, would have a tendency to travel towards the equator, moving the rest of the crust along with it. "My hypothesis," he said ten years later, in his Presidential Address of 1876, "was founded on the assumption of the globe consisting of a comparatively thin crust with an internal fluid nucleus, over which the crust could slide when from any geological cause its equilibrium was disturbed."[2] But the hypothesis under which he then appealed to physicists for a solution of the question, if not intended by him to be different from the above, has, at any rate, been so taken by Mr. Twisden,[3] and Mr. G. Darwin,[4] and, following them, by Mr. Hill; for all these gentlemen have supposed the globe *solid* from the surface to the centre. I do not think that any geologist can easily entertain this opinion; and when, in handling the subject, one omits all reference to any other possible supposition as to the state of the earth's interior, it seems to me that he is not rendering that help to his less accomplished brethren which he might render.

The causes, which lead physicists to regard the problem from their point of view, may partly be, first, that the great problem of Precession and Nutation has always been so treated. They are, therefore, already some way on their road towards the elucidation of any other question of this class. Secondly, the perhaps greatest living physicist in this kingdom has pronounced in the strongest language against the doctrine of a fluid interior. He appears, in consequence of a conversation with Professor Newcomb, to have given up the original argument against it from precession and nutation. "Interesting in a dynamical point of view as Hopkins' problem is, it cannot afford a decisive argument against the earth's interior liquidity."[5] But there remain the tides. "The solid crust would yield so freely to the deforming influence of the sun and moon, that it would simply carry the waters of the ocean up and down with it, and there would be no sensible tidal rise and fall of water relatively to land."[6] I have inquired[7] whether, taking their lagging into consideration, it is certain that the crests of the tidal waves in the ocean and in the crust would occur simultaneously at the same place: because, unless they did so, we might still have a tide relatively to land. Recently, at the Cambridge Philosophical Society, when Mr. Hill gave some illustrations corroborative of Mr. G. Darwin's results, Mr. Darwin told the meeting, in reply to some remarks of mine, that he had

[1] Proc. Roy. Soc. No. 82, 1866.
[2] Quart. Journ. Geol. Soc., vol. xxxii. Presidential Address, p. 108.
[3] Quart. Journ. Geol. Soc., vol. xxxiv. p. 35.
[4] Trans. Royal Soc. vol. 167, part i.
[5] Sir W. Thomson's Sectional Address, *Nature*, vol. xiv. 1876, p. 429, 2nd column.
[6] Ibid. [7] Quart. Journ. Geol. Soc., 1875, p. 470.

been investigating the above question raised by me. We may, thereore, hope to receive a decisive answer to it.

It does not, however, appear necessary that geologists should be concerned to inquire whether the earth is *wholly* fluid within. If there be granted a layer of fluid matter of a thickness even very small compared to the radius of the earth, that will suffice us. May not the argument for rigidity drawn from the tides, after it has received that definite weight which proper observations (yet to be made) are expected to give it, be satisfied with a rigid nucleus of radius nearly approaching to that of the entire globe? Such tides as would be formed within the liquid substratum of the crust would not be of the nature of the tides, contemplated by Sir W. Thomson as affecting the entire spheroid, but more nearly analogous to the ocean tides; since they would involve a horizontal transference of fluid backwards and forwards, and might be expected to be of small amplitude, owing to the viscosity of the substance and its confinement beneath the crust. However, even the modest requirement of a fluid substratum is denied to us. "But now thrice to slay the slain. Suppose the earth this moment to be a thin crust of rock or metal resting on liquid matter. Its equilibrium would be unstable! And what of the upheavals and subsidences? They would be strikingly analogous to those of a ship that had been rammed; one portion of crust up and another down, and then all down. I may say with almost perfect certainty that whatever may be the relative densities of rock, solid or melted, at or about the temperature of liquefaction, it is, I think, quite certain that cold and solid rock is denser than hot melted rock, and no possible degree of rigidity in the crust could prevent it from breaking in pieces and sinking wholly below the liquid lava."

If we now turn to Mr. Hopkins' Researches in Physical Geology,[1] we find that he had gone into this question somewhat fully, and held an exactly opposite opinion from the above. He considered that, so long as the matter of the earth retained a sufficiently high state of fluidity to admit of the circulation of convection currents, no crust could form: but that when, by those means, the temperature had been so far reduced that convection became arrested, immediately a crust would be formed. "Since the heat increases with the distance from the surface, while the mass is cooling by circulation, the tendency to solidification, so far as it depends on this cause, will be greatest at the surface, and least at the centre. But on the other hand, the pressure is least at the surface, and greatest at the centre; and consequently the tendency to solidify as depending on this cause will be greatest at the centre, and least at the surface." For want of experimental evidence, "the only conclusion at which we can arrive is this, that if the augmentation of temperature with that of the depth be so rapid that its effect in resisting the tendency to solidify be greater than that of the increase of pressure to promote it, there will be the greatest tendency to become *imperfectly fluid,*

[1] Trans. Roy. Soc. part ii. 1839, quoted in his Report to the British Association, 1848.

and afterwards to solidify, in the superficial portions of the mass: whereas, if the effect of the augmentation of pressure predominate over that of temperature, this transition from perfect to imperfect fluidity, and consequent solidity, will commence at the centre."

Assuming the latter to be the case, when the mass should have arrived at that stage of cooling that "a solid nucleus had been formed, surrounded by an external portion of which the fluidity would vary continuously from the solidity of the nucleus to the fluidity of the surface, where, at the instant we are speaking of, it would be just such as not to admit of circulation; . . . a change would take place in the process of solidification which it is important to remark. The superficial parts of the mass must in all cases cool the most rapidly, and now (in consequence of the imperfect fluidity) being no longer able to descend, a *crust* will be formed on the surface, from which the process of solidification will proceed far more rapidly downwards, than upwards on the solid nucleus." And in a note to the Report,[1] he writes thus decidedly: "Supposing the earth once to have been fluid, it must be now, or have been at some antecedent epoch, in that state in which a solid exterior rests on an imperfectly fluid and incandescent mass beneath. It is important to know that this state of the earth, assuming its original fluidity, is one through which it must necessarily have passed in the course of its refrigeration, whatever might be the process of its solidification."

These remarks of Mr. Hopkins deserve serious consideration, and are not lightly to be set aside. They are entirely independent of his subsequent calculations by which he considered he had proved (and was until very lately indeed considered by the greatest mathematicians to have proved)[2] that this crust was not at the present time a thin one, but had grown to the thickness of at least not far short of a thousand miles; even if its downward growth had not already met the upward growth of the solid central nucleus.

The reasoning by which Mr. Hopkins concluded that a crust would form (and he clearly supposed it would be supported also), seems to be assailable only on the supposition that upon solidification a sudden considerable contraction, and consequent increase of density, would occur, which would enable the fragments to sink in a fluid, too viscous to admit of the sinking of portions cooled to the *verge* of solidification.

It is practically seen that a crust can be formed and supported upon liquid lava by what is known to happen in the crater of Kilauea. This is of an elliptical form, three miles in its longer diameter: consequently the attachment to the cliff-like sides can have little effect in supporting the crust over so large an area. Moreover, this has been observed to rise and sink with variations in the level of the lava, showing that it really rests upon the fluid support. "The floor of the pit is described as usually presenting a crust over a vast pool of lava, which is from time time broken through by a fresh upboiling of the incandescent mass beneath.

[1] Page 48. [2] *Vide suprà*, p. 292.

It cools and hardens so rapidly on exposure, that it may be walked upon within a few hours after coagulating. Sometimes upwards of fifty small cones and craters, more or less in activity, have been counted on the floor of this great pit. They were from fifty to a hundred feet high."[1] "It is nine miles in circumference, and its lower area, which not long ago fell about 300 feet, just as ice on a pond falls when the water below it is withdrawn, covers six square miles."[2] In the case of the earth's crust, it seems probable that the lateral pressure, to which the upheavals and subsidences are due, would have the effect of keeping the fragments of the crust close pressed together, and so checking anything like a general intrusion of lava between them. Its exit would probably be confined to here and there volcanic vents, more numerous, no doubt, and larger, in ancient times, but still in general character like those of the present day.

The argument for the existence of a fluid layer beneath the present crust appears to me to be considerably strengthened by a comparison which I have myself made between the actual inequalities of the earth's surface and those which could have been formed by lateral pressure if the globe had cooled as a solid body.[3] This has led me to the conclusion that some condition has been present which has admitted of its shrinking much more than it could have done if it had cooled as a solid; nay, probably more than mere cooling alone can account for. I surmise therefore that the interior has contained water, which has escaped through volcanic vents as superheated steam, and that the earth's volume has been diminished in that manner by the actual transference of matter from beneath to above the crust. What may be the exact amount of decrease of volume which might be obtained by transferring a given quantity of water from beneath to above the crust, it is not possible to say; because we do not know the properties of water as it may exist under such circumstances of heat, pressure, and chemical combination as obtain within the earth. But it is obvious that a larger contraction can be accounted for by aid of this supposition than without it. I received a letter from Mr. Scrope in October, 1876, very shortly before his death, in which he commented on this suggestion. "There is one of the points you put forward which never struck me before, but which now appears to me most valuable; viz., that the enormous amount of steam that has escaped from the interior in early times, as well as down to the present, has been, and is, the cause of those *subsidences* of the crust, to which the basins of seas and oceans, and the crumplings of the terrestrial rocks are owing, far more than to any general contraction of the nucleus by cooling."

It is known also that mountain chains have most of them been ridged up and folded much more than the country bordering upon them. Now this peculiarity implies a slip of the superficial strata

[1] Scrope's Volcanos, p. 477, ed. 1862.

[2] Miss Birt's Hawaiian Archipelago. See *Nature*, vol. xi. p. 324.

[3] Trans. Cambridge Phil. Soc., vol. xii. part ii., abstracted in Geol. Mag. N.S. Vol. I. p. 60.

over whatever it be that underlies them. It is obvious that a more or less perfectly fluid substratum is required to give this capability of slipping. Indeed the nearest analogy to the formation of a chain of mountains seems to be found in the crushing together of the adjacent edges of two sheets of floating ice.

I have thus, I think, shown that the supposition of a liquid layer beneath the crust of the earth is not a supposition that is so wholly untenable as has been represented, and that, as far as *authority* (that blind guide) can determine the question, we have it on both sides. I recur therefore to my original proposition, that physicists should be moved to consider what elements of change in the position of the earth's crust as regards latitudes might be introduced under the influences acting upon it, by the existence of a considerable degree of mobility between the crust and a solid nucleus owing to the intervention of a liquid stratum. The solidity of the crust being supposed due to cooling, and that of the nucleus to pressure, I would consider the crust thin, and the fluid substratum also thin. I would consider the crust and the fluid of sensibly the same thicknesses at the equator as elsewhere, taking the equatorial bulge as existing in the solid nucleus. This supposition would seem admissible, because we have volcanos in low as well as in high latitudes, showing that, if they be connected with a liquid substratum, that cannot be much more deep down in the one region than in the other. Moreover, the ratio of the centrifugal force to gravity being small, it is not likely that the upper limit of the pressure necessary to induce solidity should be at an appreciably greater depth below the surface at the equator than at the poles. I would consider the crust flexible, but *for the purposes of the problem* not horizontally compressible further than would allow it to fit the spheroid in any new position so that it should move all together. Then I would inquire, a portion of it having become thickened by assemblages of foldings near together, in other words by the elevation of continents, what effect these would have upon the position of the crust as regards the axis of rotation of the whole, supposed fixed in space.

This is, in short, Dr. Evans's original problem, which he endeavoured to solve by experimental means.

But the question I would put is, whether, supposing the crust free to move under forces as small as those which this change of form would bring to bear upon it, the effect would be (not that the protuberances would be brought towards the equator, as in Dr. Evans's wheel), but that the crust would tend to be carried into such a position that the axis of symmetry of the solid nucleus and of the crust together (*i.e.* their axis of greatest moment of inertia) would tend to coincide with the axis of rotation. If this were so, the nucleus being spheroidal, the crust would eventually become so placed with regard to the axis of rotation that that would coincide with its axis of principal moment of inertia. If, however, the crust were free to obey this tendency only to a certain degree, being checked, partly by the rigidity of its parts not allowing it to adapt itself freely to its altered position on the spheroid, partly by the viscosity of the liquid, and partly by decrease in the moment of the forces shifting it; then, the crust having progressed as far as it was permitted to do, would stick fast, and the whole would commence to rotate as a solid body, and the principal axis, being that neither of the crust alone, nor of the solid nucleus alone, but of the whole mass, would come to coincide with the axis of rotation.

Now when I look at the distribution of land on the globe, and observe it chiefly confined to one hemisphere, and arranged in a manner, not symmetrical, but with an approach to symmetry as regards moment of inertia about the axis of rotation, I fancy I see an indication of the truth of the supposition advanced.

It is possible that a future generation of geologists may be able to gather some information regarding the interior of the earth from the mysterious phenomena of magnetic variation. But at present we cannot hope for much help from this quarter. The temptation, however, is too great to forbear quoting from Captain Evans's lecture a very striking passage.[1] "These are a few facts relating to secular changes going on in two magnetic elements within our own time; and what are the inferences to be drawn therefrom? They appear to me to lead to the conclusion that movements, certainly beyond our present conception, are going on in the interior of the earth; and that so far as the evidence presents itself, secular changes are due to these movements, and not to external causes. We are thus led back to Halley's conception of an internal nucleus or inner globe, itself a magnet, rotating within the outer magnetised shell of the earth." This is, to say the least, in very remarkable accordance with the conclusion I have proposed to draw from geological and other considerations.

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## III.—A List of the Madreporaria of Crickley Hill, Gloucestershire, with Descriptions of some New Species.

By Robert F. Tomes, F.G.S., Corr. M.Z.S.

A CONSIDERABLE part of the material forming the present communication was collected as long ago as 1862, but the specimens obtained at that time, with the notes thereon, remained in abeyance until quite recently. On a renewed examination of them, it appeared that much of what had been noted down had not been superseded, and this induced me to go through the whole of it again, and make such additions and modifications as seemed necessary to bring it into its present form. And I have done this in the hope, and indeed in the belief, that it will serve a twofold purpose. It will make known some forms which are new, not only to the particular locality, but also to the catalogue of English species; and it will furnish a more complete list than has yet appeared of the species from one of the best-known Coral-reefs of the Inferior Oolite.

The Crickley Coral-reef, according to Dr. Wright, is the lowest of

[1] Lecture at the Royal Geographical Society, March 11, by Capt. F. J. Evans, C.B., F.R.S., Hydrographer to the Admiralty, *Nature*, May 16, 1878.

three which are found in the Inferior Oolite of the Gloucestershire Hills, and it rests on the Pisolite or Pea-grit.

I can hardly expect that the following list comprehends anything like all the species which occur at Crickley: most likely it does not even include all those which have been collected, and are known; but it is more ample than any one which has yet been published, and may serve as a basis to which additions and corrections may from time to time be made. All the specimens to which I shall refer were collected by the Rev. P. B. Brodie, F.G.S., Mr. J. W. Kirshaw, F.G.S., and myself, during a very few visits made by us to that locality. Many of the species were found *in sitû;* but some of them, though of unquestionable authenticity as far as the locality is concerned, cannot be placed stratigraphically, having been found amongst the weathered *débris* on the slopes beneath the section. All are referable to two families, the *Astræidæ* and the *Fungidæ.*

Family Astreidæ.

Montlivaltia Holli, Duncan, Supp. Brit. Foss. Cor., pt. iii. p. 16, pl. 1, fig. 5–6.

Two examples only of this species have been taken directly from the Coral-bed by myself, when they were associated with the following species, *Montlivaltia Painswicki.* Both of them exhibit the calicular peculiarities mentioned by Prof. Duncan, but externally they differ not only from his figure, but also from each other. They are attached to a worn piece of a *Thamnastræa,* and are very crooked and rugose. They have much the appearance of springing from one root, and their general aspect is very suggestive of some species of *Thecosmilia.* In both specimens the margins of the septa are entire and quite smooth.

Montlivaltia Painswicki, Duncan, Supp. Brit. Foss. Corals, pt. 3, p. 17, pl. 2, fig. 13.

Of this species several examples were found associated with the foregoing in the Coral-bed, and all of them possess the characters attributed to this species by Prof. Duncan. They vary a little, chiefly in not being equally compressed, but in every instance the calice is more or less irregularly ovoid, with a slight tendency towards a lobular outline, and a narrow linear base. In all of them the principal septa meet and unite in the centre of the calice, but without forming the least indication of a columella.

Montlivaltia trochoides, Edw. and Haime, Ann. des Sci. Nat. s. 3, vol. x. p. 229 (1848); Brit. Foss. Cor. pt. ii. p. 129, pl. xxvii. figs. 2–4.

All the varieties figured by MM. Edwards and Haime in their History of British Fossil Corals have been met with at Crickley. Most of the specimens I have seen have lost their epitheca, and have been otherwise rubbed and damaged.

Montlivaltia lens, Edw. and Haime, Hist. Brit. Foss. Cor. pt. ii. p. 133, pl. xxvi. figs. 7 and 8.

Previously to 1862 I had received many examples of this species, some of which were said to have been obtained from Crickley, but they were unaccompanied by any information respecting the particular bed from which they were taken. However, in that year I took two examples from the *Cephalopoda* bed at that place, and I have no doubt, from the similarity of the matrix in all of them, that they had been derived from the same bed. At Dover's Hill, near Chipping Campden, the species was found abundantly a few years since in a layer of soft rufous sandstone underlying the *Cephalopoda* bed. It was at this place associated with another species of *Montlivaltia* and a species of *Thamnastrœa.*

CYATHOPHYLLIA OOLITICA, n.s.

The genus *Cyathophyllia* was established by M. de Fromentel[1] for a species of Coral from the upper beds of the Middle Lias of Normandy. It resembles the genus *Montlivaltia,* excepting that it has a large papillated columella. Since the appearance of the description of the genus by M. de Fromentel, Dr. E. A. Reuss[2] has added another species to it, in a paper on the Miocene Corals of Hungary. By means of the excellent figures and descriptions furnished by these authorities, I have been enabled to determine a much worn coral from Crickley, and add another species to the genus, which I describe thus.

The corallum has a much depressed turbinate form. The calice is sub-ovoid, slightly convex, with a sub-central shallow fossula, which is filled by a large oblong and papillated columella. The septa are numerous, about 160 in number; they are straight, pretty uniform in thickness, and about 50 pass into the columella. There is considerable irregularity in the degree of development of the newer cycles of septa. The columella is porous and papillose, and the processes of which it is composed are curved and twisted, somewhat as they are in the *Parasmiliœ.* It is oblong in the direction of the greatest diameter of the calice, of which it is one-fifth of the length.

The margins of the septa have been worn off, but their connexion with the columella is very clearly shown. The epitheca appears to have deen destroyed, and the costæ exhibit between them well-marked and rather numerous dissepiments.

Height of the corallum $\frac{1}{2}$ inch; diameter of the calice $1\frac{3}{4}$ inch.

THECOSMILIA GREGARIA, M'Coy, sp. *Montlivaltia gregaria,* M'Coy, Ann. & Mag. N. H. ser. 2, vol. ii., p. 119 (1848).

All the specimens I have examined have been found amongst the rubbish which, having fallen from its proper bedding, had become weathered. It is a most variable species, ranging from a branching to a compact coral. Prof. Duncan observes of it: "A careful study of the *Thecosmilia* of the Inferior Oolite at Crickley has enabled me to distinguish five very remarkable varieties of *Thecosmilia gregaria,*" and again he remarks: "There are specimens of *Thecosmilia gregaria* in Dr. Wright's collection, which, had I not had a considerable series to examine from other sources, might have been associated

[1] Pal. Franc. Coral. Terr. Juras. p. 86, pl. 18, f. 1.
[2] Sitzung. Math. Naturw. Akad. Wiss. lxi. Bd. 1, Ab. 37, Taf. iv. f. 1 (1870).

with Reuss's new genus, *Heterogyra*, together with *Symphyllia* and *Latimæandra*."[1]

I think, however, that, variable as this species may be, some of the so-called varieties will eventually prove to be distinct. When all the young forms of these several varieties have been recognized, and a full series of examples of different ages have been compared and their successive growth traced out, it is more than probable that their distinctive characters will assume a more definite form.

Thecosmilia Wrighti, Dunc., Supp. Brit. Cor. pt. iii. p. 17, pl. v. figs. 1, 2, 3, 4 (1872).

Many fragments of this species occur in the Coral-bed at Crickley, but none that I have met with have been sufficiently perfect to give any indication of the height attained by the corallum, but their straightness and the unfrequency of forked pieces may be taken as suggestive of a tall species. The straightness and parallel arrangement of the branches in Prof. Duncan's figure would seem to point to the same conclusion.

Thecosmilia ramosa, d'Orbig., Prodr. de Paleont. t. i. p. 292. (1850).

A small species of this genus, of which I have as yet seen but one specimen, appears to resemble the *T. ramosa* of M. d'Orbigny in the size of its calices, and in having four cycles of *unequal* septa.

To the very brief description of M. d'Orbigny I add the following:—

Corallites free, much curved, and enlarging slowly. They are very rugose, and each one is incased in a thick epitheca, strongly marked with concentric folds and wrinkles.

Walls thick, calices round, but becoming ovoid before dividing into two. Septa irregular. The first and second cycles meeting in the centre of the calice, thicken and unite and form an irregular but rather large columella.

Height of the corallites from one to two inches, diameter of the calices three to four lines.

It was obtained from the Crickley Coral-zone by my friend Mr. J. W. Kirshaw, F.G.S., and kindly given by him to me.

Isastræa tenuistriata, Edw. and Haime, Brit. Foss. Cor. pt. ii. p. 138, pl. xxx. fig. 1; Hist. Nat. des Coral. tom. ii. p. 532; E. de From. Etude Polyp. Foss. p. 226.

Astrea tenuistriata, M'Coy, Ann. & Mag. Nat. Hist. ser. 2, vol. ii. p. 400 (1848).

Of this rather remarkable species I have up to the present time only made a superficial examination, but I am led to suspect, from the appearance of some of the calices, that more intimate research would reveal characters not wholly those of typical *Isastrææ*. On some parts of the calicular surface a distinct flat depressed space is visible between the calices, over which the septa (costæ?) pass, and unite with those of contiguous calices. This species appears, as far as conclusions may be drawn from external appearances only, to hold some affinity with the genus *Confusastræa*.

[1] Supp. Brit. Fos. Cor. pt. iii. p. 2, 1872.

ISASTRÆA EXPANSA, n.s.

Many fragments of a very thin and expanded species of *Isastræa* were taken by myself at Crickley before I succeeded in obtaining a sufficiently perfect specimen for description. By carrying away some large lumps of the soft cream-coloured Coral-bed, and extracting with care the corals contained in them, I obtained good examples of many of the species mentioned in this paper, and amongst them a series of the species which I now describe under the above name.

Corallum consisting of a thin irregular horizontal plate supported on a sub-central peduncle. The upper or calicular surface is undulating and has a very thin outer margin. The peduncle is short, irregular in form, and very rugose. Both it and the inferior surface of the expanded part of the corallum have a well-developed epitheca, which is strongly marked with concentric folds or ridges.

The calices over the peduncle are somewhat hexagonal, but as they approach the outer boundary of the corallum they assume a somewhat rounded, ovoid, or lozenge shape, their greatest diameter being in the direction of their progressive growth, that is, from the centre towards the circumference of the corallum. They are rather superficial, and the intercalicular or mural species consist of thick rounded ridges, constituting the walls.

The septa are about 33 in number, and form four cycla, of which the fourth is incomplete. Those of the first and second cycla approach nearly to the centre of the visceral cavity and have their inner extremities thickened sufficiently to give something the appearance of a coronet of pali. The septa of the third cycle are about two-thirds of the length of those of the first and second, and those of the fourth are quite short. All of them have a rounded superior margin and a granulated surface, and they are continued over the top of the tumid walls and are continuous with those of contiguous calices.

Diameter of the calices $1\frac{1}{2}$ to 2 lines.

The general form of this species is sufficient to distinguish it from all other British species of *Isastrææ*. The form too of the calices is distinctive, more especially in the worn examples, in which the thick walls are most visible. In these the calices are seen to have but little angularity, but resemble shallow cups having a pretty regularly rounded or ovoid form.

The species to which it bears the greatest resemblance by the structure of its calices and walls is the *Isastræa foliacea* of M. de Fromentel, from which however it is specifically quite distinct.

LATIMÆANDRA FLEMINGI, Edw. and Haime, Brit. Foss. Cor., pt. ii. p. 136, pl. xxvii. f. 9.

Examples of this species are not rare at Crickley, and some of them exhibit a peculiarity which is not common in the Oolitic *Isastrææ*.

The near connexion of the genus *Latimæandra* with the genus *Isastræa* has been noticed by MM. Edwards and Haime in their History of British Fossil Corals (part ii. p. 137), and again in their

Histoire Naturelle des Coralliaires (tome ii. p. 543). In the latter work they observe: "Ce groupe est très-voisin des Isastrées: il s'en distingue par l'absence d'épitheque et la tendance de ses polyperites à former des séries plus ou moins longues."

Prof. Duncan, in his Supplement to the History of British Fossil Corals (part iii. p. 18), observes of this species: "Many portions of the corallum do not present serial calices, and if such fragments were found separate, they would necessarily be associated with the genus *Isastræa*."

Neither of these palæontologists, nor yet M. de Fromentel, appear to have observed a peculiarity which is seen in some specimens of *Latimœandra Flemingi* from Crickley, and that is, the total absence of a common or enclosing wall, and the consequently exposed and open condition of the inferior extremities of the corallites. This is not a common character amongst the Oolitic *Isastrœæ*, though it prevails amongst the Liassic species.

Clausastræa consobrina ? Ed. and Haime.

Pal. Foss. des terr. Paleon. p. 107 (1851). Hist. Nat. Cor. tom. ii. p. 552 (1857).

E. de From., Intro. Etud. Pol. Fos. p. 281 (1858–61).

*Synastrœa consobrina*, d'Orb., Prod. de Pal. Franc. t. i. p. 293 (1850).

I have seen one specimen only of a coral which I refer with some doubt to the above species. It was taken from the Coral-bed by myself in 1862. It agrees so closely with the description given by MM. Edwards and Haime of *Clausastrœa consobrina*, as well as with that of M. de Fromentel, that I have referred it to that species, though with some doubt.

The corallum has the thin and expanded form so common amongst the Crickley corals. The calices, though superficial, are symmetrically round, and the septa somewhat exsert, with a small but well-defined circular fossula. The septo-costal rays are continuous in adjacent calices, though not as in the genus *Thamnastrœa*, but often meeting and uniting at an angle on the mural region. The walls are either wholly wanting or merely rudimentary, and the dissepiments are well developed and domeshaped.

M. de Fromentel places the genus *Clausastrœa* amongst the *Zoantharia Tabulata* on account of the dissepiments taking the position of tabulæ. In my specimen, though they are on nearly the same planes, they preserve the character of true dissepiments, and can scarcely be said to form tabulæ.

Family Fungidæ.

Genus Thecoseris, E. de From.

M. de Fromentel thus characterizes this genus. Corallum elevated and regularly turbinate. Calicular fossa, when it exists, round. Most commonly the septa are united in the centre of the calice, and form a false columella. They are fine, numerous, often anastomozing, and finally denticulated. They are never exsert, and the calice is generally concave. The epitheca is strong, well developed, in folds, and reaching to the margin of the calice.

The type is *T. patellata*, E. de From. et Fery, Paleont. Franc. Terr. Juras. pl. 58, fig. 2 (1869). From the Middle Lias.

The description of the genus appears in the Palæont. Franc. Terr. Crétacée, p. 367.

THECOSERIS POLYMORPHA, n.s.

Corallum simple, variable in form, but always more or less turbinate, and non-attached.

The wall is thin, its superior margin prominent, undulating and sometimes almost foliaceous.

Costæ, when exposed by abrasion of the epitheca, numerous, delicate, and with lateral synapticulæ feebly developed.

Epitheca thick, rugose, and exhibiting distinct rings of growth.

Calice shallow, concave, and extremely variable in outline. Fossula small, but round and well defined.

Septa rather numerous, somewhat flexuous, irregular in thickness, and not diminishing as they approach the calicular fossula. Those of the younger cycles pass into those of the older ones.

Synapticulæ feebly developed.

Height of the corallum $\frac{1}{2}$ to $1\frac{1}{2}$ inches. Diameter of the calice 1 to $1\frac{1}{2}$ inches. This appears to be a common species in the Coral-bed at Crickley.

The genus *Thecoseris* appears to be nearly related to *Trochoseris*, but differs most essentially from it in having no columella. In this respect it resembles the genus *Turbinoseris* as defined by Prof. Duncan.[1] In the only example appertaining to this latter genus which I have been able to examine (a specimen of *Turbinoseris De Fromenteli*, Duncan, from the Lower Greensand of Atherfield), the calice is a little convex with a slightly everted margin, and with a shallow round fossula. It bears very considerable resemblance to some examples with unworn calices, of *Podoseris mamilliformis*, Duncan, from the Red Chalk of Hunstanton,[2] but it differs essentially in not having any epitheca. The *Podoseris mamilliformis* is a particularly variable species, as far as form is concerned, many specimens having a turbinate form with a depressed calice, and a small but well-marked central fossula. Yet all which I have examined (in number considerably more than a hundred) have had a well-defined epitheca. But the existence of an epitheca in this species is rendered less important in a generic point of view by the feeble degree of its development in another species described by Dr. Duncan from the Oolite of Dorsetshire, under the name of *Podoseris constricta*.[3] Besides the want of a well-developed epitheca, this species further departs from the original definition of the genus *Podoseris* by having a small instead of a large base. These peculiarities help to bring *Podoseris* in nearer relationship with *Turbinoseris*; and with a more ample list of species representing the genera *Thecoseris*, *Podoseris*, and *Turbinoseris*, it is quite probable that they may require reconsideration.

[1] Supp. Brit. Fos. Cor. pt. ii. No. 2, p. 42 (1870).
[2] Supp. Brit. Fos. Cor. pt. ii. No. 1, p. 25 (1869).
[3] Supp. Brit. Fos. Cor. pt. iii. p. 24 (1872).

Thamnastræa Defranciana, Edw. et Haime, Pol. des Terr. Paleon. p. 110 (1851); Brit. Foss. Corals, pt. ii. p. 139, pl. 29, fig. 3 and 4; Hist. Nat. Coral. tom. ii. p. 561. *Astræa Defranciana*, Mich. Icon. p. 9, pl. 2, fig. 1 (1840).

In Michelin's figure the calices are more concentrically arranged than in any example I have met with. This appears to be a common species at Crickley.

Thamnastræa Terquemi, Edw. et Haime, Pal. des Terr. Paleon. p. 110 (1851); Brit. Foss. Coral, pt. ii. p. 140, pl. xxx. fig. 2; Hist. Nat. Coral. tom. ii. p. 579.

In most of the species from Crickley the basal portion is much less symmetrical than in the figure given by Edwards and Haime in their History of British Fossil Corals. In many examples the epitheca is gone, and the whole of the inferior part of the corallum has a more or less lobular form, and the outline of the calicular surface has a corresponding degree of irregularity in its outline.

Thamnastræa Mettensis, Edw. and Haime, Brit. Foss. Corals, pt. ii. p. 141, pl. xxx. fig. 3; E. de From., Introd. à l'Etude Pol. p. 214.

This appears to be abundant at Crickley.

Thamnastræa Lyelli? Edw. and Haime, Brit. Foss. Corals, pt. ii. p. 118, pl. xxi. fig. 4.

I refer a dendroid species from Crickley to this species with great hesitation. Only one fragment has been examined, and it is so very crystalline that no internal examination can be made.

The columella appears to be rudimentary or wanting. The confluent septo-costal rays are arranged transversely with the axis of the branches, and the calices have a much clearer definition than those of most of the species of *Thamnastræa*.

Thamnastræa Fromenteli, n.s.

Corallum thin and expanded. Above, somewhat convex with irregular prominences; below, concave. There is no epitheca. The calicular surface has one central large calice, surrounded by many small ones scattered irregularly about. They are small, superficial, and indistinct, and a very few septa enter into their composition. There is no columella. The septo-costal rays are very thin and flexuous. They have a very distinctly radiate arrangement, and are traceable from the large central calice outwards to the margin of the corallum. The synapticulæ are abundant, thicker than the septa from which they spring, cuneiform, and their points meet in the interseptal loculi.

Diameter of the corallum $3\frac{1}{2}$ inches; height of the corallum in the centre $\frac{3}{4}$ inch.

The large central calice and the slight development of the surrounding small ones, with the radiate disposition of the very thin septo-costal rays, will at once distinguish this species.

One specimen only has been examined by me. It was obtained at Crickley, but its position in the section was not ascertained.

Dimorphastræa dubia, E. de From., Introd. à l'Etude des Polyp. Fos. p. 224 (1858—1861).

Several examples of a Coral have been obtained directly from the Coral-bed of Crickley which appear to answer to the description of the *D. dubia* of M. de Fromentel, which is recorded by him as occurring in the Coralline Oolite of Nathein, in Wurtemburg. They all differ from that species, however, and indeed from the genus *Dimorphastræa,* in having a well-developed epitheca. In well-preserved specimens the calices are placed in the bottom of circular grooves, surrounding the central, or parent calice. These grooves have something the appearance of the calicular furrows in *Latimæandra,* but in much worn or polished specimens the calices are seen to be at equal distances from each other, and in circles. In no example is there any trace of columella. The large central calice, and the regular disposition of the smaller ones around it, will identify the species with the above genus; though the calicular furrows might at first sight lead to the supposition that it is referable to some species of the genus *Oroseris.*

The foregoing species, with the exception of *Montlivaltia lens,* occur, there is no doubt, in what Dr. Wright designates the Lower Coral Reef of the Gloucestershire Hills; for although some of them were not taken directly from the reef, but were found weathered out on the slope below, the nature of the still partially investing matrix points out pretty clearly the source from which they were derived.

The occurrence of *Montlivaltia lens* in the Cephalopoda-bed, at Crickley and near Chipping Campden, and associated at the latter place with two other species of Corals, is interesting as showing an approach to those conditions of oceanic life which became shortly afterwards so highly favourable to the growth of Coralline existence.

A peculiarity observable in many of the Crickley Corals is their thin and expanded form. This is more especially the case with *Isastræa expansa, Clausastræa consobrina, Thamnastræa Mettensis* and *Th. Fromenteli.* In some others this peculiarity, though less distinctly marked, is not wholly absent. *Thamnastræa Defranciana, Th. Terquemi,* and *Dimorphastræa dubia,* while characterized by a somewhat turbinate form, are nevertheless often so much depressed as to become almost discoid, with a somewhat foliaceous margin.

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## IV.—The late Professor Phillips on the North Devon Rocks; with an Introductory Note

By Townshend M. Hall, F.G.S.

The Meeting of the British Association at Plymouth has not unnaturally been the means of directing attention to some of the most complex points of Devonshire geology, and of reviving the discussion as to the age and position of the Devonian series in North and South Devon. Mr. Jukes, it will be remembered, died in 1869. Had he lived longer, his energy of purpose would doubtless have led him to carry on the work he had begun, until he could either prove the correctness of his views, or satisfy himself that the generally accepted classification was, after all, the right one.

The followers of Jukes seem to confine themselves to those portions only of the district which he had more specially studied—North Somerset, Lynton and Pickwell Down; searching in almost hopeless despair amongst the lower rocks, instead of beginning at the other end of the scale, with the Millstone-grit, and tracing the beds downwards. As a result, the fossiliferous beds of the Upper Devonian have been almost entirely neglected, and their relation to the Carboniferous slates passed over.

Possibly the real question at issue may not be settled in a satisfactory manner until we get a new Ordnance Survey, with a six-inch map on which to lay down our observations; but in the mean time I would submit that there was one geologist whose opinions on the subject, had they been made equally public, would have been received with all the respect due to his great local knowledge, and his well-known caution in drawing inferences from facts. The author of the "Palæozoic Fossils of Cornwall, Devon and West Somerset" can no more use his pen in defence of the Devonian rocks; but as one of his former pupils at Oxford, I know well the unfailing interest he retained in everything relating to Devonshire, both before and after Mr. Jukes's first paper was read to the Royal Geological Society of Ireland, in May, 1865.

The last visit paid by Prof. Phillips to North Devon was in August, 1869. At the close of the Exeter Meeting of the British Association, an excursion was made by about 200 of the members to Bideford and Westward Ho! and having been selected as the guide for the occasion, I asked my old master some days previously if he would add a few words to what I was about to say with reference to the North Devon rocks. This, with his usual kindness, he agreed to do; and the short address he then gave was, it is believed, the only one in which he publicly stated his views on the controversy which at that time had apparently been brought to a termination by Mr. Etheridge's exhaustive paper,[1] and by the subsequent death of Mr. Jukes. Now the question has been re-opened, it seems only fair that the opinions of one who was in every way so well qualified to form and express them should be put on record for future use in a more permanent shape than that of a newspaper cutting.

As regards the accuracy of the following reprint, I may say that the proofs were corrected by Prof. Phillips; and on subsequently receiving copies of the *North Devon Journal* in which it appeared, he wrote to me from Oxford:—"The account is very accurate; and I wonder how any stenographer could take down the *επεα πτεροεντα* from the perch of rocks. In two parts only is there anything which has struck me as requiring amendment,—when Murchison and Sedgwick are mentioned, they seem to oppose one another. Not so. They should be quoted as opposing De la Beche's classification, and rightly so. Say 'immediately his conclusion was disputed by,' and again a little earlier, for 'terms then unknown,' read 'then *not* unknown.'"[2]

[1] Quart. Journ. Geol. Soc. vol. xxiii. p. 568.
[2] These corrections are shown in italics.

ADDRESS DELIVERED BY PROFESSOR PHILLIPS AT WESTWARD HO! NORTH DEVON, AUGUST 26, 1869.

Ladies and Gentlemen,—All that we now see in action—all the force of the waters and all the effect of the wind—has been in operation through an immensity of time. At some time removed from the present was formed the deposit which we have just been looking at. At some earlier time than that the sea-coast underwent great changes of level with reference to the water, and here you have one of the most conspicuous examples of a raised beach, proving to you that at the time when it was formed the action of the water was of the same nature as now it is in the distribution of these large pebbles, that these pebbles are of the same order, coming from the same quarter, and finally ground down to masses of about the same magnitude. You see, also, that the ancient deposit of the beach was of considerable thickness, and over the pebbles other matters have increased which deserve a careful scrutiny. At an earlier date than that this country was raised out of the water under which it was formed. All the features of North Devon and South Devon primarily depend on the movements which have taken place from below, which have uplifted ridges of mountains and formed in the alternating spaces hollows. Then there has come over the surface the enormous action of long time and atmospheric waste, and what we see at the present moment in every hill and valley, every waterfall and every stone, is not merely the great force of ancient nature which sketched out the forms of continents and islands, but the subsequent action of ordinary daily, hourly, atmospheric agencies upon the surface; so that many persons who have satisfied themselves of the importance of diluvial agency in producing great changes on the surface of the earth are very much in the habit of believing that there is no necessity for supposing that anything else than rain and rivers is required to produce all the main changes, all the principal features of our interior geography. Now, if you keep in your minds the fundamental proposition that every one of these stratifications we see on the north and on the south have been formed under the influence of the sea, that these almost vertical rocks were at one time laid flat, that they have laminations in which are shells of the period, and many marks proving beyond a doubt the original nearly-horizontal deposition of this strata, you will perceive that in order to have the first elementary notions of the relation of the different parts of the land one to the other, we must study those monuments that are so clear (and nowhere so clear as on this coast), of the fact of the immense elevation of the ancient sea-beds in order to produce the main features of our interior land.

Now, as you pass from this part to the northern coast there are some undulations in the general course of the stratification, but in a general manner they rise from the northward, and the lower strata of North Devon are found on the northern shore. Afterwards as you pass by the stratification of Bideford and that district in which the Culm deposits occur (as referred to by Mr. Hall), as you go southward the stratification undergoes many undulations, some parts of the sea-bed having been raised and some parts having been depressed, until you reach the granite of Dartmoor, where the stratification turns up against the great mass of granite rock upon which until recently opinion was not divided. It has always been imagined to be a mass of rock fused by the hot interior of the globe, pressed upwards with great energy, and throwing up its stratification towards the north and the south. But all human opinions change,—even the opinions of scientific men who are supposed to have most prejudiced notions with reference to their theories. Now, some scientific men believe that the granite is the product of water and not of heat. I must tell you frankly that I do not believe them—on the contrary, I think there is evidence—absolutely perfect evidence—that the granitic rocks were produced at a very great depth in the interior of the earth. No doubt water was present, but the granite was never dissolved in masses by its action. They were solidified in the presence of water, and they contain small quantities of water in some of their crystals; a thing no more to be wondered at than that there is air in the sea and water in every one of the stones we see around us. Now, the stratification which rests on this granite has been perfectly traced, and in all the districts of Devon there is no more interesting study than this county to the northward. And what is curious is the fact that the stratification is clear in its continuity. In the Bideford strata you have the lower Coal deposits, and at Barnstaple you arrive at the Carboniferous age: then you have the Pilton strata, mentioned by Mr. Hall, until you come to the strata of Lynton and the red rocks of the Foreland. The stratification is in regular order,—on the whole running from north to south, and the sequence of the different strata is well known, though I trust it will be better known in a few years by the continued labours of my friend Mr. Hall, to whom we are extremely obliged for acting as our conductor on this occasion. He lives on the spot which is so celebrated for its fossils—Pilton is his native home, and I am sure that in future years we shall live to acknowledge his efficient and painstaking researches. What are these strata which have been pointed out to us? When Sir Henry De la Beche, in the year 1836, published his book on "The Geology of Cornwall, Devon, and West Somerset," he considered that at that time terms, which were then [*not*] unknown, such as "the transition series of rocks" and the "greywacke group," could be applied to large portions of this county of Devonshire; but when afterwards sections of the district were obtained with the greatest accuracy, it was found that he was apparently quite wrong in his interpretation of the whole of the strata from Bideford, southward to Dartmoor, for he referred these deposits to an age much older than the deposits on the northern side, and they are now known to be much younger. You may think this was a great fault, but in my opinion it was a small one considering the wonderful accuracy of the greater part of his work. It was in consequence of a discussion on his observations that I first had an opportunity of making an acquaintance with North Devon, for immediately there was a dispute between [*his* *conclusion was disputed by*] Professor Sedgwick and Sir Roderick Murchison, and there was a doubt on the subject, I received a commission from the Government to investigate the matter, being supposed to be an impartial kind of person who was not disposed to accept any conclusion very hastily, whilst giving to every one the right to form an independent judgment of his own. I was sent for the purpose of expressing an opinion on the point, and in consequence I published a book on the subject.

With reference to the country to the North, still the question remains, "What are we to call it?" Many are disposed to say that a greater portion of the stratification of North Devon might be joined with those great series of rocks containing the anthracite, or culm, in the neighbourhood of Bideford, and become a part of the Carboniferous system. Others, on the contrary, think that some portions, especially to the northward, ought to be joined to the Silurian series. Now, I think that scientific men are often greatly mistaken as to the features of particular tracts of country. You know the general history of Belgium—how 1,800 years ago it was peopled by tribes who settled on a soil foreign to themselves, and they have held it as well as they could against the Germans (the Silurians) on the one side, and the French (the Carboniferous series) on the other. Well, at the time when France swallows up Belgium, or when, more probably, France and Germany take a slice each, then I hope (and not before) we shall have settled this question about the stratification of North Devon. The two sections are very powerful and rather aggressive kingdoms, and it is difficult to defend the North Devon territory against the demands of the Carboniferous strata above and the Silurian strata below. As I would never desert a falling cause (if this be one), I still declare myself in favour of the independence of North Devon, and assert that there are strata which are neither Silurian nor Carboniferous—that of themselves they are worthy of a separate study, deserving separate names—and that their history is remarkably interesting, connected as it is with some of the most important movements on the crust of the globe. Those movements were subsequent to the date of the deposition of these rocks. Since these rocks were deposited a large portion of the features of South Wales has been produced, the channel between South Wales and Devon has been formed, and there has also been produced the hollow that exists on the southern side of North Devon, and all the undulations in the interior of the country; all Dartmoor and the Cornish rocks have been raised since the days when the North Devon deposit was produced in the ancient sea. Gentlemen of Devon, never give up the independence of your country, hold to the North Devon series, and if it is the case, as Mr. Godwin-Austen invites us to believe it is, that they do not belong to the Old Red Sandstone series, do not let us conclude that because they do not belong to that particular class, they are nothing at all. Let us keep the North Devon series distinct, as a separate characteristic—it is a most interesting study, and, what is best of all, it is as yet not completely explored. Let us encourage by every means in our power local residents, who have the best means at their command of completing a history which so many have attempted to give. Let us doubt anything except this, that the North Devon strata are worthy of a separate study, a separate name, and a separate history.

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## V.—Discovery of an Ancient "Kitchen Midden" near Dundee.

By James Durham, F.G.S.

RECENT operations in connexion with the Dundee Harbour works have been the means of opening up a very interesting section of superficial deposits.

In order to fully understand the position of the section, it must be remembered that on either side of the Firth of Tay, as well as round most part of the Scotch coast, are a series of raised beaches or gravel terraces succeeding each other at vertical intervals of from five to ten feet. Up to a hundred or a hundred and fifty feet above the sea-level they are well marked, and are readily observed by the most inexperienced eye. Above this height the old sea-levels can be traced by means of wave-worn cliffs; but owing to the influence of denudation, the terraces are extremely difficult to distinguish, or are altogether wanting. Among the lower terraces none are usually more conspicuous than a beach about 25 or 30 feet above the Ordnance Survey datum-line, but at a point about a mile east of Dundee, called the Stannergate, it is by no means so prominent as at other parts of the estuary; the denudation of the slope behind having buried it to a considerable depth under a mass of unstratified earth and stones, so that, instead of the abrupt terrace, the Stannergate braes slope gently to the top of the cliff at the sea-margin. It is to the burying of that old beach that we are indebted for the preservation of the interesting remains that have just been brought to light.

A cutting in connexion with the works referred to has exposed a section from the very top of these superficial deposits to a considerable distance into the rock beneath. The section is approximately as follows:—

| | |
|---|---|
| Earth containing Stone Coffins, Urn, etc. ..... ..... ..... | 3 to 4 feet |
| Earth undisturbed ..... ..... ..... ..... ..... ..... ..... ..... | 7 ,, 8 ,, |
| Shell-bed ..... ..... ..... ..... ..... ..... ... ..... ..... | 1 ,, 2 ,, |
| Gravel of raised beach ..... ..... ..... ..... ..... ..... ..... | 1 ,, 2 ,, |
| Rock | |

The discovery of the stone coffins created considerable interest among local antiquaries, two of them being what are termed short cists, in which the body was buried in a sitting position, with the knees brought up to the chin, which is supposed to be a very early manner of interment; while an urn or rude earthen vessel, which was found in one of them, is said to be of a very ancient type; but it is to the shell-bed that the chief interest attaches. Very soon after its exposure it was observed that, not only were the shells all broken, but that, while the greater part of them were that of the mussel, in no case were the valves found in their natural position, and at the same time a very large proportion of them were those of adult animals. This led to a closer examination of the bed, when it was found that mixed with the shells was a large quantity of burned wood, with bits of burned horn and bone, while many of the shells themselves had evidently been subjected to a strong heat. These facts left no doubt that the bed was in many respects similar to the famous Danish "Kjokken Möddings." During the progress of the engineering operations, which have completely removed the shells, a tolerably careful search was made for other traces of humanity, and no implements that could safely be accepted as such were discovered, although some bits of broken bone, the tyne of a deer horn, and, most important of all, part of a long bone of some animal unmistakably split artificially, probably either with the object of extracting the marrow or of fashioning an implement, rewarded the search.

As the "Midden" thinned out in any direction it was found to be interbedded with the gravel of the old beach, and in one part was overlain by a stratum of sand and gravel of some thickness, in which could be found traces of burned wood and shells similar to those of the "Midden" below, just as we would expect to find it if the heap had been formed close to high-water mark where it could be reached by the waves of an unusually high tide, which would throw the gravel over the shells, and partly interstratify them.

These facts would seem to prove that not only was the shell mound a haunt of early man before the ten or twelve feet of earth, etc., was laid down upon it, but that the rude people who found in the shells of the sea-shore their most convenient food-supply, lived when the 25-feet beach was at the sea-level, and consequently when the geography of the country was different from what it is to-day.

I am obliged to Prof. H. Alleyne Nicholson for kindly identifying some of the fragments of shells sent to him as being those of *Mytilus edulis, Purpura lapillus, Tellina balthica* and *Littorina littorea,* all recent species, and the bit of deer horn as being "almost certainly" one of the tynes of the antler of the red deer.

## NOTICES OF MEMOIRS.

### I.—M. Th. Fuchs on the Origin of False-bedding.

In the "Report of the Imperial Geological Institute of Vienna," September 30, 1877, M. Th. Fuchs points out that when by great storms, or high tides forced up against the land by strong winds, the sea is massed up along the coast (as it is sometimes to the height of 10, 20, and even 30 feet), the coarser detritus, as shingle, blocks, and boulders, is suddenly swept down to a lower level, even over the mud-zone, by the deep and strong counter-current of the displaced water finding its level again; thus giving rise to false-bedding on a large scale and apparent local unconformity.—T. R. J.

### II.—East-African Ammonites.

(Report Imper. Geol. Instit. Vienna, Sept. 30, 1877.)

A series of Jurassic Ammonites from the East Coast of Africa, collected by Dr. Hildebrandt, offer a striking analogy to those from the *Acanthicus*-zone of East-India, published by Dr. Waagen. Some *Planulati* among them may possibly be identical with *Ammonites torquatus* or *Amm. bathyplocus.*—Count Marschall.

III.—F. Karrer on Miocene Foraminifera in the Philippines.

(Imper. Geol. Instit. Vienna, Report, September 30, 1877.)

The fossil Foraminifera at Luzon, in the Philippines, are *Nodosaria, Cristellaria, Polymorphina, Globigerina,* etc., characteristic of a rather deep-sea deposit. The same forms having been found in the Nicobar Islands, Java, Celebes, and Borneo, an extensive Miocene sea may be supposed to have existed from the Nicobars to Luzon.—Count Marschall.

IV.—Dr. O. Lenz—On West-African Geology.[1]

(Report Imper. Geol. Instit. Vienna, December 4, 1877.)

Some Organic Remains have been collected near Landana and Caconge, 5° 15′ Lat. S., and 12° Long. E. Greenwich, on the West Coast of Africa. The coast there consists of steep cliffs and rocks, rising to a height of 50 feet. Inland is a series of hills, projecting from the West-Africa chain, which ranges N.-S., and is composed of gneiss, mica-schist, talc-schist, quartzites, etc. This is the "Sierra do Cristal" or "Sierra complida" of the Portuguese. On the banks of the Gaboon and Ogowe Rivers (from 1° Lat. N., to 1° Lat. S.) this promontory consists of horizontal calcareous sandstones with Cretaceous fossils. Further South, it appears as a deep-brown, friable, very fine-grained ferruginous, and non-calcareous oolite. In it are Corals, with *Leda, Mactra, Tellina, Cardium,* etc. Remains of Fishes, very well preserved, have been found near Landana, about 36 miles south of Point Padron. A large slab of grey, fine-grained, somewhat argillaceous sandstone contains the vertebræ and skull, with teeth and branchial arches, of a large Fish, more or less compressed. Teeth, also, and dorsal spines of a Ray, a tooth of a Crocodile, a coprolite, and a very large and probably Cretaceous *Nautilus,* were collected in the same locality. The last-mentioned fossil was full of a light-coloured limestone, crowded with small Gasteropods and Bivalves. The cliffs, 20 feet high, along the coast of Ambrisetta, east of the mouth of the Congo (or "Livingstone") River, are composed of a light-grey limestone abounding with shells of *Ostrea.*—Count Marschall.

## REVIEWS.

I.—Records of the Geological Survey of India, Vol. xi. Pt. i. 1878.

The "Records" of this Survey enter upon their second decade with a quarterly part of nearly three times the usual size; the first for 1878, containing, besides the Annual Report of the Superintendent, several important papers by the officers: "Notes on the Geology of the Upper Godaverí Basin" (Hughes); "Notes on the

[1] See Geol. Mag. New Ser. Vol. IV. p. 27.

Geology of Kashmir, Kishtawar and Pangi" (Lydekker), both accompanied by coloured geological maps; "Notices of Siwalik Mammals" (Lydekker); "The Palæontological Relations of the Gondwána System, a reply to Dr. Feistmantel" (Blanford, W. T.); "Note on Punjab Erratics" (Wynne); and the usual lists of additions to the Library.

In the Annual Report the Superintendent describes the nature of the Survey operations, and the progress made since the last Report was published, entering at some length into the subject of explorations for coal, which seem to have had in general rather negative results. The recent Survey of the Sind Tertiary marine and freshwater rocks are fully noticed, and the suggestion made that the Sind sections may furnish an important clue to the horizons of contemporaneous strata in the Tertiary region of the sub or outer Himalayan belt, where it is admitted that the changes in the composition of the deposits, and the great disturbance which these have undergone, present a constant obstacle to tracing contemporaneous zones.

The latter part of the Report is occupied by a disclaimer, in language sometimes strong, at others most liberal, of responsibility for the views and opinions conveyed in the papers which it becomes the duty of the Superintendent to edit in the Survey publications.

Mr. Hughes's paper treats of a district chiefly occupied by the Gondwána system, and prominently so by the interesting Kota-Malerí sub-group with its interesting fossil fish *Lepidotus, Dapedius*, and *Ceratodus*, and the reptiles *Parasuchus* and *Hyperodapedon*, together with a considerable number of fossil plants. These Gondwána rocks are underlain by the Vindhan and Metamorphic groups, all being unconformably overspread by outliers of the bedded "Deccan trap group."

Mr. Lydekker's paper and map give us what is likely to develope into a complete Geological Survey and description of the interesting country and neighbourhood of Kashmir, a thing which has been long desired. Mr. Lydekker's map still shows blank spaces, but so much ground has been covered that a fair estimate can be formed of the chief geological formations to be found.

The oldest of these are gneiss rocks seen at Darcha, the Wardwan valley and Zanskar range, and in the range of Dhaoladar. The age of this gneiss is undetermined, and it is overlain by another gneiss formation seen in Kulu, on the Pir Panjál range, and overlying the former gneiss at Wardwan and Lanskar range.

Resting on this are the slates and limestones of Pangí and Lahúl, overlain by the Lower Pir Panjál slates, and the lower slates and trappoid rocks of the Kashmir valley and its vicinity. Newer than these are the trappoid rocks of the Wular lake neighbourhood, upon which come the Upper Pir Panjál slates, shales and trappoid rocks; both groups being considered of Upper Silurian age, while the underlying slates and trappoid rocks mentioned above are classed as Lower Silurian and Cambrian (?).

Above this slate and trappoid series is a mass of limestones, slates, and sandstones, varying so much in lateral development that the author considers it may have had separated areas of accumulation. It is the first rock group in the ascending series found to be fossiliferous and belongs entirely to the Carboniferous formation. In it are represented, the author thinks probable, not alone the Krol and infra-Krol groups of the Simla area, but the Carboniferous Kuling series of Dr. Stoliczka's Himalayan sections to the east.

Overlying this great Carboniferous formation come limestones, dolomites, sandstones, and slates, mostly developed in the higher mountains towards the interior of the Himalaya, and which are of Rhætic and Triassic age, representing, perhaps, the Lilang series of Stoliczka.

In a former paper, by himself and Mr. Medlicott, to which the author refers frequently, the relations between the Pir Panjál and other Kashmir rocks and those forming the Outer Himalayan Tertiary belt, are shown, the disturbed state of the junction being as great as is usual along the Tertiary belt. From this inwards the whole of the great Pir Panjál range is described as being an inverted or overthrown anticlinal arch bearing from the Kashmir valley towards the outer Himalayan border hills.

Within the valley itself the "Karewah" superficial beds, which are of great thickness, and which have usually been regarded as lacustrine, are referred here to a late Tertiary period, apparently upon the evidence of a constant dip as high as 20°, with which they rest upon the inner flanks of the Pir Panjál range. The question seems mainly to depend upon the point whether this angle of dip has been produced by disturbances (forming perhaps part of the movements accompanying the production of the Himalayan chain), in post-Tertiary times, or whether superficial beds can be deposited from water at angles so high as 20°. Evidence from organic remains is not adduced.

The trappoid rocks of this country have been thought by some previous observers, notwithstanding their trappean and amygdaloidal aspect, to be merely varieties of metamorphosed strata, and by others to be veritable traps. The author, after numerous opportunities of studying this question, favours the latter view, and regards some of the denser kinds as genuine igneous rocks, an opinion borne out by the microscopic examinations of Colonel McMahon. The whole of these trap rocks are older than Carboniferous.

In the absence of palæontological testimony to produce from the lower rocks of Kashmir, and until it is shown that they have been traced into continuity with fossil-bearing beds in other parts of the Himalayan exposures, even more caution might have been used in applying the terms "Cambrian" and "Silurian" to these ancient slates, gneiss, etc.

One very interesting point is the discovery by Mr. Lydekker of numerous rolled boulders of an unknown gneiss in the lower slates, which rest conformably upon the gneiss of these mountains—a fact indicating the previous existence of very ancient metamorphic ranges, whence he thinks these blocks may very possibly have been transported by ice or rafted among the roots of trees. The break which this would establish in the Himalayan series seems hitherto to have escaped all observers—but the field is a wide one.

The next paper by the same author is entirely palæontological. It records the most important and interesting additions to the Siwalik mammalian fauna made by Mr. Theobald from the rocks of the Rawul Pindi plateau during the preceding season as well as some from Sind collected by Messrs. Blanford and Fedden. Corrections of previous determinations are also given.

Among the genera noticed and described are, *Macacus, Mastodon, Stegodon, Dinotherium, Hyotherium, Anthracotherium, Rhagatherium, Chœromeryx, Merycopotamus* — like animals, *Sus, Camelopardalis, Hydaspitherium, Rhinoceros, Listriodon, Hystrix, Rhizomys, Felis, Hyœna, Mellivora, Meles* (?), *Amphicyon, Hyœnarctos,* and an alleged *Cetacean* earbone considered by Professor Flower to belong to the *Ungulata.*

One of the most important contributions to the number is Mr. W. T. Blanford's paper on the palæontological relations of the Gondwána system, a reply to Dr. Feistmantel's many recent papers on the same subject. Mr. Blanford is, on the whole, courteous, if severe, and has taken much pains to examine critically the arguments of his colleague, who is charged with making an undue use of the principle of selection in regard to his comparisons between the Indian Gondwána and European Mesozoic flora; indeed, it is stated that he employs no evidence among the mass available except that which tells in favour of his own view.

Mr. Blanford disclaims the intention to set himself up as a palæobotanist, still he has sought and found evidence to form an easily appreciable list of plants from the European Bunter, the Indian Damuda (Lower Gondwána), and the Newcastle beds of Australia, in parallel columns, which points to a very different result from that arrived at by Dr. Feistmantel as to the Mesozoic age of this part of the Gondwána formation.

The paper is a long one, and requires to be read to grasp its importance. The conclusions arrived at by the author, shortly stated, are—1st, that the evidence adduced by Dr. Feistmantel as to the Umia beds of Kach (with *Trigonia Smeii,* and *T. ventricosa,* etc.) not being Upper Jurassic is insufficient and incorrect; 2nd, that the proof for the Rajmahal group being Lias is also insufficient; 3rd, that the Panchet group and the Keuper have not been sufficiently shown of the same age or related by homotaxis; 4th, that the evidence on which the Mánglí beds are classed as Rhætic and newer than the Panchets is based upon various mistakes and omissions; 5th, that if the affinities of the plant-fossils with those in European rocks were alone regarded, the whole Gondwána system above the Karharbari group would be probably classed as of an age from Middle Jurassic to Rhætic, and the Lower Gondwána Damuda flora as newer than the Upper Gondwána Rajmahal, both Rajmahal and Panchet beds being, according to Dr. Feistmantel, most closely affined by homotaxis to the Rhætic minor European formation, though between these two Indian groups there is the greatest stratigraphical and palæontological break in the whole Gondwána system; 6th, that no evidence of value has been produced for the classification of the Damuda series as Lower Triassic (Bunter), the Damuda flora having far less in common with the Bunter or any Triassic European flora than it has with the Upper Coal-measures of Newcastle, etc., New South Wales [presumably Carboniferous]; 7th, that Dr. Feistmantel's classification of the Australian plant-bearing beds on the authority of Mr. Clarke differs materially from all the data published by Mr. Clarke himself, etc.; 8th, that the Karharbari beds must be separated from the Damudas and classed with the Talchirs; 9th, that it is unwise to come to any positive conclusion as to the Carboniferous or Triassic age of the Damuda and Karharbari beds; 10th, that the Upper Gondwánas may be equivalent to the European Jurassic series approximately, and the Lower Gondwánas to Triasso-Permian, also approximately, but close definition of minor horizons in the Gondwána system is premature; 11th, and finally, that an attempt to define geological horizons in countries remote from Europe by fossil plants alone, can only lead to error: that Dr. Feistmantel's attempt to make the Indian groups suit the European sequence is a failure, and the constant assertion that particular groups belong to distinct European subdivisions is misleading and unscientific.

Mr. Wynne's note consists only of a few lines to set himself right in consequence of an attributed ambiguity in his previous use of the word "*erratic*," in its oldest sense, for wandering fragments, the sense in which he employed it.

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II.—Conversations with Little Geologists on the Six Days of Creation. By J. W. Grover, C.E. (With a Geological Chart.)

The Preface shows this to be one of the many works which have owed their publication to the well-meant but injudicious interposition of "friends of the author." The writer acknowledges his obligations to "Hugh Miller, Dr. Buckland, and McCausland," as well as "those standard authorities Lyell, Murchison, *Figuier* (!), and Dr. Lindley." On p. 1, however, in answer to a question, "Did Moses, who wrote the Book of Genesis, understand Geology?" the author remarks, "Not as we do; he wrote as he was inspired or taught by God Himself," and adds, "I want to show you how wonderfully the formation of the earth confirms the first chapter in the Bible."

Mr. Grover follows Hugh Miller and some other geologists of a former generation, in considering the six days of Genesis to mean six long periods of time, and one of the peculiarities of the author is the rigidity with which he settles the duration of these periods. The first day includes the Cambrian, the second the Silurian periods, while the third comprises the Devonian and Carboniferous. The Permian and Triassic rocks were the work of the fourth day, and the Lias, Oolite, and Chalk of the fifth. The sixth day includes the Tertiary strata, up to the "Diluvium." Nothing is said of Laurentian or Lewisian rocks; their place, however, would evidently be with the productions of the first day. The Diluvium is described as "a deposit supposed to have been caused by an immense wave or deluge which passed over Europe and other parts of the world, especially Asia." Some more precise information as to the whereabouts of this unique formation seems desirable.

On page 3 the author appears as an extreme evolutionist. He is asked, "So God began by making the smallest and most imperfect creatures?" He replies, "Yes. . . . His great laws continue the same now, nothing great is done at once, but by slow degrees; all discoveries and inventions begin by imperfect forms in the first instance, and they grow and improve from year to year till at length they attain their full development." This comparison of the operations of the Deity with those of men gifted with mechanical ingenuity scarcely seems well chosen, though the author is doubtless to be acquitted of anything like intentional profanity. On page 9, however, Evolutionists get but scanty justice. Some of them, according to Mr. Grover, find that there is a relationship between frogs and men, "inasmuch as the frog is the only animal which has a calf to its leg." No clue is given to the authorship of this remarkable view, and we are afraid that Mr. Grover has been caught by the "chaff" of some jocular Naturalist.

Many serious blunders occur, both from want of more accurate knowledge of common facts, and also as misprints. On page 13 we read, "Foraminifera, which *is* a mass of very feebly animated matter; seen through a microscope it resembles the roe of a fish." And again, on page 5, "It is the unclouded sunbeam which strengthens the fibres of the plant, and forms the hard woody substance in trees." The remark about Foraminifera is certainly calculated to puzzle the childish understanding, while the passage about wood and sunbeams is likely to lead to the error of supposing them simply different forms of the same substance. This can hardly have been Mr. Grover's intention. The identification (p. 1) of the distinguished theologian known as St. Augustine with the Augustine who, two centuries later, converted the King of Kent, is objectionable in the interests of accuracy, though not of geology. Certainly the crudity in conception and looseness in execution of this work must ever prevent it, in its present form, from filling the place designed for it by its author, in spite of his remarkable ingenuity and good intentions.

Well said the Duke of Argyll, in reference to *popular* works on Geology, that none but our most able writers should venture to undertake them; and forasmuch as they were designed for the instruction of those but little informed upon the subject, *they should above all things be accurate.* T. V. H.

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III.—Mines and Mining in the Lake District. By John Postlethwaite. (Leeds, 1877.)

KESWICK, situated in the midst of some of the wildest and most picturesque scenery of the Lake District, is not less remarkable for the natural beauty of its surroundings than for its indigenous sources of mineral wealth, the knowledge of which is of great antiquity, some of the mines having been worked by the Romans during their occupation of this country, and probably by the Britons before them.

Both the physical features and the mineral contents of the rocks are due to the geological character of the district, which consists chiefly of the Skiddaw slates, with the associated granite and metamorphic schists, and the overlying green slates and porphyries (Borrowdale series). These rocks, elevated, indurated, contorted and faulted, have subsequently and for long ages been weathered and disintegrated by various meteoric agencies acting on the hard and soft strata,—thus producing the present irregular outline of cliff, ravine and valley, due primarily and partly to a former glacial period which has left its traces in the scored rocks, rounded hummocks, and thick accumulations of moraine materials in the present valleys, and which, as well as the other geological features, have been so ably described by Mr. C. Ward in his memoir lately published and noticed (Geol. Mag. 1877, p. 280).

On the other hand, the mineral veins and lodes are the result of those mysterious processes, deeply seated perhaps, by which the containing fissures became filled with various kinds of metallic matter, with which the Lake District abounds, for no less than 86 species of minerals have been noticed, of which 46 are metallic, and 40 non-metallic; some of them being most rare and beautiful forms. The principal mines from which these minerals have been obtained are arranged by the author in the order of the strata in which they occur, commencing with those in the Skiddaw slates, which are numerous and extensive, the veins being generally large and well mineralized, but sometimes irregular in the deposits of ore.

The mines in the green slates and porphyries are not so numerous as those in the Skiddaw slates, but some of them are much more productive. The most remarkable of these mines is the plumbago mine, which is well known to be unequalled for the purity of the graphite obtained from it; the containing vein or dyke is a species of hard trappean or diabasic rock of a peculiar nature, the deposits of plumbago occur in sops or pipes of various sizes, and not in veins. The Coniston copper mine and the Greenside lead mine are in the same formation, the latter being one of the most valuable mines in the North of England.

The mining field of Caldbeck Fells is in the porphyritic syenite, in which seven distinct mines have been opened. Of these the most important and productive is the Roughtengill, both as regards the quantity and variety of its ores and minerals. Besides the metallic mines, the Caldbeck district includes the north-western portion of the West Cumberland coal-field, in which a small seam of coal was wrought as early as 1790.

The work is illustrated by a map of the mining field of the Lake District, with section and plans of the principal mines, together with a synopsis of the State papers relating to the mines and smelting works near Keswick. The author, practically acquainted with the mining district, and evidently interested in the mineral development of his country, has produced this concise and useful account of the past and present mining industries around Keswick, their failures and successes, and their present abeyance, in order to perform a patriotic duty, by correcting a very prevalent, but erroneous, notion respecting the mineral deposits of the Lake District, with the hope of directing more attention to the subject, so that it may at some future time become as famous for its mineral productions as it is now for its beautiful scenery. J. M.

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IV.—ILLUSTRATIONS OF FOSSIL PLANTS; being an Autotype Reproduction of Selected Drawings, prepared under the supervision of the late Dr. LINDLEY and Mr. W. HUTTON, between the years 1835 and 1840, and now for the first time published by the North of England Institute of Mining and Mechanical Engineers. Edited by G. A. LEBOUR, F.G.S., Newcastle-on-Tyne. Royal 8vo., containing 64 Illustrations in Autotype, with Portrait of W. Hutton. (1877: Published for the Institute by Andrew Reid, Printing Court Buildings. London: Longmans & Co.)

THE "Fossil Flora" of Lindley and Hutton has been for more than forty years a standard work on British fossil plants, and it is hoped that it may be still further supplemented by the publication of the promised fourth volume under the able superintendence of Mr. W. Carruthers, F.R.S., containing not only corrections of former descriptions, the result of new observations, but the addition of many new and interesting forms which have appeared in this MAGAZINE, and other Geological Journals, besides the special memoirs by Mr. Binney in the Palæontographical Society and Prof. Williamson in the Transactions of the Royal Society since the publication of the original work.

The study of fossil botany has been much advanced during late years, by the issue of numerous and important memoirs on fossil plants both in Europe and America, so that ample means exist for the further comparison of the British forms with those of other continental areas. Among the more general works of interest are Dr. Dawson's Acadia, Rogers's Pennsylvania, Prof. L. Lesquereux on the Cretaceous and Tertiary floras of America; those by Geinitz, Mougeot, Ettingshausen, Saporta, and Göppert, the botanical parts of the Palæontographica, and of the Paléontologie Française, Schimper's Paléontologie Végétale, M. Grand Eury's "Carboniferous Flora of Central France," and other papers in the Spanish, Italian, and Russian journals.

The present volume may be considered as an *addenda* to the "Fossil Flora," as it consists of a series of sixty-four plates, reproduced by the autotype process, of a selected number of original drawings, which had evidently been prepared for a continuation of that work.

These drawings formed part of a large collection belonging to the late Mr. W. Hutton, and were presented to the North of England Mining Institute by Mr. Hubert Laws. Having been prepared under the supervision of the late Dr. Lindley and Mr. W. Hutton between the years 1835 and 1840, but not published, the Council of the Institute resolved to publish the more important figures, of undescribed, rare, or beautiful specimens, most likely to prove of value to the student of fossil botany, and hence the origin of the above work, the editing of which was entrusted to Mr. G. A. Lebour, who has appended to each plate a few brief remarks as to the general character of the specimen figured, without a distinct diagnosis, but with slight references to allied forms, and the localities from whence they were obtained. The editor has, however, made use of the notes referring to the plates left by the authors of the "Fossil Flora," or their correspondents. The specimens figured were mostly obtained from the Coal-measures of the North of England, and consist chiefly of species of *Neuropteris*, *Pecopteris*, *Sphenopteris*, with forms of *Sigillaria*, *Lepidodendron*, *Calamites* and their foliage, and also some excellent examples of those ambiguous remains of plants referred to roots and rootlets. It may be useful for those who may hereafter wish to compare the specimens referred to in this work, to know that the original carefully executed drawings are in the Library of the Institute, while the fossils themselves have been deposited by the Council in the Museum of the Natural History Society of Newcastle. J. M.

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V.—Thesaurus Devonico-Carboniferus: The Flora and Fauna of the Devonian and Carboniferous Periods. The Genera and Species Arranged in Tabular Form, showing their Horizons, Recurrences, Localities, and other Facts. By J. J. Bigsby, M.D., F.R.S., F.G.S., etc.

Another work has appeared from the pen of one of the oldest and perhaps one of the most painstaking and laborious of living geologists. In 1868 Dr. Bigsby published his Thesaurus Siluricus, and he now issues his new volume of the "Thesaurus Devonico-Carboniferus," consisting of 450 pages of closely-printed matter, arranged in tabular form, the result of eight years' continuous and almost uninterrupted labour. To attempt to estimate by the size of the volume the work accomplished by the author, large as it is, is totally to under-estimate the immense labour bestowed and the minute and careful research required to produce so great a compendium of palæontological facts as that attempted and so successfully carried out by Dr. Bigsby. Such works are "lasting monuments of the learning, labour, zeal, and research" of their authors.

The author of the Thesaurus has chronicled with faithfulness the palæontological results of all that has been done in Devonian and Carboniferous geology in Europe, Asia, and America, tabulating under their respective families every known genus and species, with their chief localities, and *one*, and sometimes two, references, commencing with the Plantæ in each of the two geological periods, and then ascending through the whole Zoological series, from the Protozoa to the Pisces and Amphibia. The great value of this Thesaurus to the student consists in the (almost in every instance) correct reference given to the species under their respective genera, thus furnishing us with a census of the Fauna and Flora of the Devonian and Carboniferous rocks of the world. Those who know the detailed labour, time, and anxiety involved in making 80,000 to 100,000 references will best appreciate the service rendered by Dr. Bigsby to Palæontological science. The contributions of every author are made manifest, but so voluminous and complicated are works of reference now, that it is not easy, nay, at times it is next to impossible (except in public libraries), to obtain complete evidence of the labours of foreign geologists, so as to arrive at facts and reliable data as to the history and distribution of life through time and space. Such, however, is the painstaking and laborious nature of the task requisite in order to collect and verify every species in the Thesaurus just issued by Dr. Bigsby.

The plan is comprehensive and clear, showing at once the distribution of every species known to have existed, and which now constitutes the Devonian and Carboniferous Fossil Fauna and Flora. The results of appearance and distribution, etc., are given in separate tables at the end of each sub-kingdom or class. This *résumé* embodies both the geographical or distribution in space, as well as the geological and stratigraphical, or distribution in time.

It is the tabulation of such results that leads to clear generalizations, and, as in the present case, affording a knowledge of the distribution of Devonian and Carboniferous life over the globe, and this is the aim and end of Dr. Bigsby's work. No library of reference, public or private, should be without such works. Certainly no geological library can be said to be complete that does not contain upon its shelves such works of reference as will enable the student in natural science to obtain correct and ample data both certainly and readily.

Dr. Bigsby has greatly aided palæozoic palæontologists by the compilation both of his Thesaurus Siluricus, in 1868, and the present contribution on the Devonian and Carboniferous groups, no genus or species seem to have been omitted or overlooked. Fourteen countries or areas in Europe, and fifteen in America, have been selected as geographical localities for the distribution of the Carboniferous species. The European are Ireland, Scotland, England, Belgium, France, Rhenish Prussia, Westphalia, Silesia, Hartz, Moravia, Bohemia, Saxony, Russia in Europe, and the Altai. In America Arkansas, Kansas, Nebraska, Missouri, Iowa, Michigan, Illinois, Indiana, Ohio, Kentucky, Tennessee, Pennsylvania, Nova Scotia, Cape Breton, New Brunswick. The labours of the numerous American and European Palæontologists who have enriched the literature of their respective countries are faithfully chronicled, and the horizons and localities of their fossils given.

In the Silurian Thesaurus of 1868, Dr. Bigsby discussed with great ability, under his "facts and observations," seven questions or subjects of high importance to a right understanding of the distribution, and laws of life through all time. These may well be consulted with reference to the present volume, bearing as they equally do upon its whole contents. Those chapters on locality, first appearance, extinction of species, migration, and recurrence, in the Silurian Thesaurus, although not given in the Devonian and Carboniferous volume under notice, should be referred to as masterpieces of logical deduction. Continental and American geologists and authors will gladly hail the work before us, and wish that length of life could be spared to its author to complete in the same manner the Secondary formations of the world. The geologist deals with time, and time has dealt kindly with the author of the Catalogue of the Flora and Fauna of the Devonian and Carboniferous periods. Great is the muster-roll of past life that he has chronicled through time in this volume, nor will the chronicler of the future fail to inscribe among the names of the great and good in geological science, who have by their patient labours contributed to the store of our common knowledge, the honoured name of John J. Bigsby.

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VI.—Stanford's Geological Map of London and its Suburbs. Scale 6 inches to a mile. The Geology compiled from the Maps, etc., of the Geological Survey by J. B. Jordan. 24 Sheets in Portfolio, with Index. (1878.)

THE Geological Survey, having published no other map than the ordinary one, on the scale of an inch to the mile, Mr. Stanford has boldly come forward to supply the want of a larger one, using for the purpose his well-known "Library Map of London." The work is substantially the same as that which forms the surface of the large model of London in the Museum of Practical Geology, and as Mr. J. B. Jordan was employed in the colouring, etc., of that model, our enterprising publisher has done well in securing his services in the compilation of the geological information.

The area of the district represented may be judged from the places shown near its corners, which are as follows:—Wimbledon on the S.W., beyond Hampstead on the N.W., Leyton on the N.E., and Beckenham on the S.E. The formations shown by distinctive colours are Alluvium, Brickearth, Gravel and Sand, Lower Bagshot Sand, London Clay, Oldhaven Beds, Woolwich and Reading Beds, Thanet Sand, and Chalk. It will be seen, therefore, that those surface-deposits of gravels, brickearth, etc., which have so much effect on the character of the ground, although of small thickness, are not neglected, but are shown equally with the thicker formations (London Clay, Chalk, etc.). It has not been thought advisable, however, to distinguish the gravels of different ages (though this is done on the above-mentioned London Model), those of older date occurring in such very small areas as to make the expense of employing two additional colours not worth incurring.

Of course this map does not pretend to compare for accuracy with the "Six-inch" Maps of various northern parts issued by the Geological Survey, the geology on which has been actually surveyed on that scale; it is of necessity, to a great extent, an enlargement of the "One-inch" Map, as far as the geology is concerned; though not altogether, as may be seen from the description of the London Model in the little "Guide to the Geology of London," published by the Geological Survey.

Each of the 24 sheets can be had separately, or the whole mounted together on a roller, so that the map can be made available for the pocket, the book-case, or the lecture-room.

So far as we know there is no other case, but that of the late Mr. Sanders' large map of Bristol, of the publication of a geological map on so large a scale, as a private enterprise—such things are left to Government Surveys—and therefore we trust that in the present instance both publisher and compiler may be well rewarded. W.

## REPORTS AND PROCEEDINGS.

Geological Society of London.—I. — May 8, 1878. — Henry Clifton Sorby, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Glacial Phenomena of the Long Island, or Outer Hebrides." 2nd paper. By James Geikie, Esq., LL.D., F.R.S., F.G.S.

In this paper the author gave some additional notes on the glaciation of Lewis, and a detailed account of the glacial phenomena of Harris and the other islands that form the southern portion of the Outer Hebrides. Additional evidence was adduced to show that Lewis had been glaciated from S.E., to N.W., and the shelly boulder-clays and interglacial shell-beds of that part of the Long Island were described in detail. Harris, North Uist, Benbecula, South Uist, Barra, and the other islands that go to form the chain of the "Long Island," were successively described under the headings of Physical features, Geological structure, Glaciation, Till or Boulder-clay, Erratics and perched blocks, Morainic débris and Moraines, Freshwater lakes and Sea-lochs. Numerous bearings of striæ, which abound, were given, and these were held to prove that the whole Outer Hebrides have been glaciated by ice that flowed outwards from the mainland of Scotland. The position of abundant *roches moutonnées* points to the same conclusion, and this is still further supported by the "travel" of the Till. That deposit is generally absent or very sparingly present on the rock-faces that look towards the mainland, but it is heaped up in their rear, and spreads over the lower tracts that slope gently towards the Atlantic. On the west side of the islands not a few boulders occur in the Till which have been derived from the east; and the same is true of certain erratics lying loose at the surface of the ground. The islands are well glaciated up to a height of 1600 feet above the sea; and the line of demarcation between the glaciated and non-glaciated areas is extremely pronounced. Above 1600 feet the hills show rugged, splintered, jagged, and sometimes serrated tops. The author regarded the Till or boulder-clay as the morainic material that gathered underneath the ice, and proof of this is given. Erratics and perched blocks are very numerous, and most of these, as well as much of the morainic *débris*, are believed to have been dropped where we now find them during the final melting of the ice-sheet. It was shown, however, that certain erratics and perched blocks and some well-marked moraines are due to local glaciers, as are also some of the striations in a few of the mountain-valleys. The origin of the rock-basins, which are now lakes, was discussed, and attributed to the erosive action of ice. To the same cause were assigned the rock-basins which occur in certain of the sea-lochs.

In concluding, the author pointed out that we may now arrive at a true estimate of the thickness attained by the ice-sheet in the north-west of Scotland. If a line be drawn from the upper limits of the glaciations in Ross-shire (3000 feet) to a height of 1600 feet in the Long Island, we have an incline of only 1 in 210 for the upper surface of the ice-sheet; and of course we are able to say what thickness the ice reached in the Minch. Between the mainland and the Outer Hebrides it was as much as 3800 feet. No boulders derived from Skye or the mainland occur in the Till of the Outer Hebrides, and this was explained by the deflection of the lower portion of the ice-sheet against the steep wall of rock that faces the Minch. The underpart of the ice that flowed across the Minch would be deflected to right and left against the inner margin of the Long Island; and the deep rock-basins that exist all along that margin are believed to have been scooped out by the grinding action of the deflected ice. Towards the north of Lewis, where the land shelves off gently into the sea, the under strata of the ice-sheet were able to creep up and over the district of Ness, and thus gave rise to the lower shelly boulder-clay of that neighbourhood, which contains boulders derived from the mainland. The presence of the overlying interglacial shell-beds proves a subsequent melting of the ice-sheet, and a depression of the land for at least 200 feet. The overlying shelly boulder-clay shows that the ice-sheet returned and overflowed Lewis, scooping out the older drift-beds and commingling them with its bottom moraine. The absence of kames was commented upon, and shown to be inexplicable on the assumption that such deposits are of marine origin; whilst if they be of torrential origin their absence is only what might be expected from the physical features of the islands. The only traces of post-Glacial submergence are met with at merely a few feet above present high-water mark.

2. "Cataclysmic Theories of Geological Climate." By James Croll, Esq., LL.D., F.R.S. Communicated by Prof. Ramsay, LL.D., F.R.S., F.G.S.

The author commenced by calling attention to the great diversity of the hypotheses which have been brought forward for the explanation of those changes in the climate of the same regions of the earth's surface which are revealed by geological investigations, such as alterations of the relative distribution of sea and land, of the ecliptic, and of the position of the earth's axis of rotation, all of which, he maintained, have proved insufficient or untenable. Sir William Thomson has lately maintained that an increase in the amount of heat conveyed by ocean-currents, combined with the effects of clouds, winds, and aqueous vapour, is sufficient to account for the former prevalence of temperate climates in the Arctic regions, and this view, the author stated, he had himself been contending for for more than twelve years. He thinks, however, that alterations in the excentricity of the earth's orbit is the primary motive cause, whilst Sir William Thomson believes this to be the submergence of circumpolar lands, which, however, in Miocene times, appear to have been more extensive than at present. He pointed out that a preponderance of equatorial land, as assumed by Sir Charles Lyell to account for the milder climate of Arctic regions in Miocene times, would rather tend to loss of heat by rapid radiation into space, whilst water is remarkably powerful as a transporter of heat, so that, in this case, equatorial water rather than equatorial land is needed.

In speaking of the glacial climate, the author maintained that local causes are insufficient to explain so extensive a phenomenon. He indicated that we are only too prone to seek for great or cataclysmic causes, and although this tendency has disappeared from many fields of geological research, this is not the case in all. His explanation of the causes of a mild climate in high northern latitudes is as follows:— Great excentricity of the earth's orbit, winter in perihelion, the blowing of the south-east trades across the equator perhaps as far as the tropic of Cancer, and impulsion of all the great equatorial currents into northern latitudes; on the other hand, when, with great excentricity, the winter is in aphelion, the whole condition of things is reversed; the north-east trades blow over into the southern hemisphere, carrying with them the great equatorial currents, and glacial conditions prevail in the northern hemisphere. Thus those warm and cold periods which have prevailed during past geological ages are regarded by the author as great secular summers and winters.

3. "On the Distribution of Ice during the Glacial Period." By T. F. Jamieson, Esq., F.G.S.

The author believes that a study of the distribution of ice during the Glacial period proves that the greatest accumulations of snow took place in precisely those districts which are now characterized by a very heavy rainfall, and he pointed out how exactly this is in accordance with the views of Prof. Tyndall as to the conditions most favourable to the development of glaciers. In support of this conclusion he reviewed the phenomena presented by the most highly glaciated districts of the British Islands, of Scandinavia, and Europe generally, and of Asia and North America, and contended that in every case his opinion is borne out, the districts which are now remarkable for an excessive rainfall having been formerly centres of dispersion for great systems of glaciers. The notion of a polar icecap he held to be opposed to many well-known facts; and he discussed the distribution of various forms of life during and since the Glacial epoch, with the object of determining whether the drainage of ice from the great polar basin was effected by means of the depression of Davis's Straits or of Behring's Straits. The evidence appeared to him to be in favour of the former channel.

II.—May 22, 1878.—Henry Clifton Sorby, Esq., F.R.S., President, in the Chair. The following communications were read:—

1. "On the Serpentine and Associated Igneous Rocks of the Aryshire Coast." By Prof. T. G. Bonney, M.A., F.G.S., Professor of Geology at University College, London, and Fellow of St. John's College, Cambridge.

In a paper published in Q. J. G. S. xxii. p. 513, Mr. J. Geikie states that the rocks of this district are of sedimentary origin, a felspar-porphyry being the "*maximum* stage of metamorphosis exhibited by the felspathic rocks," and the diorite, hypersthenite, and serpentine being all the result of metamorphism of bedded rocks. This view is also asserted in the catalogue of the rocks collected by the Geological Survey of Scotland. The author had seen specimens of rocks from this district which so closely resembled some from the Lizard, that he visited the Ayrshire coast in the summer of 1877. The conclusions formed in the field have since been tested by microscopic examination. He finds that several, at least, of the group of "dioritic" rocks are of igneous origin, and are dolerite and basalt, since they contain augite, not hornblende. The serpentine is undoubtedly an intrusive rock, the evidence being abundant and remarkably clear. One specimen can hardly be distinguished at sight from the black serpentine of Cadwith (Lizard); the resemblance also is most striking when the rock is examined chemically and microscopically. Examination of different varieties shows the serpentine to be, like that of Cornwall, an altered olivine-enstatite rock. The rock called hypersthenite is also intrusive. The author found no hypersthene. There are two varieties—one a remarkable rock, consisting mainly of large crystals of diallage, a gabbro extremely rich in this mineral and almost free from felspar; and a gabbro of later date, much resembling the ordinary gabbro of the Lizard, the felspar being converted into a kind of saussurite, and some of the diallage into hornblende. The "felspar-porphyries" appeared to the author in the field to present all the characters of true igneous rock, to be associated with tuffs, and to be unconformable with the above-described group of rocks. Microscopic examination placed their igneous character beyond doubt. There are also some basalt-dykes of later date than the above. The author is accordingly of opinion that the principal conclusions of the paper referred to above are not warranted by either stratigraphical or lithological evidence. He considers it probable that the "felspar-porphyry," like so much of that in Scotland, is of Old Red Sandstone age, and that the serpentine is of later date, but Palæozoic.

2. "On the Metamorphic and Overlying Rocks in the Neighbourhood of Loch Maree, Ross-shire." By Henry Hicks, M.D., F.G.S.

The rocks in the neighbourhood of Loch Maree have been described by various authors, but chiefly and most recently in papers communicated to the Geological Society by Prof. Nicol, of Aberdeen, and by Sir R. Murchison and Prof. Geikie, of Edinburgh. The views held by these authors in regard to the order of superposition of the rocks are well known to be greatly at variance, not only as regards some of the minor subdivisions, but in relation to the actual age of nearly the whole of the rocks to the east, or those forming the Central Highlands. The older geologists and, more recently, Prof. Nicol, hold the view that the Central Highlands consist almost entirely of the old fundamental (pre-Cambrian) gneiss, or rocks of that age; whilst others, represented by the late Sir R. Murchison and by Prof. Geikie, say that the rocks forming the whole of the Central Highlands are of much later date, and for the most part of Silurian age. In the present communication the author endeavours to show, from results obtained by him recently by a careful examination of a section extending from Loch Maree to Ben Fyn, near Auchnasheen, that the interpretations previously given are in some important points incorrect, and that this has been to a great extent the cause of such very diverse opinions.

The section described by him runs for some miles along the north shores of Loch Maree, is then continued in a S.E. direction along the heights opposite Kilrochewe and across Glyn Laggan, and then in an easterly direction through the heights on the north of Glyn Docherty to Ben Fyn and the range of mountains to the north of Auchnasheen.

On the western and for some distance along the north shores of Loch Maree the Lewisian rocks (fundamental gneiss series) are seen to consist chiefly of reddish or greyish gneiss and hornblende- and mica-schists. The strike in these beds is more or less continuous from N.W. to S.E., varying occasionally to N. and S., and they dip generally at a high angle and are much contorted. Resting unconformably upon this gneiss series, and forming here the upper part of the mountain Slioch (about 4000 feet high), are the Cambrian conglomerates and sandstones, made up chiefly of masses of the rocks below cemented together by a comparatively unaltered matrix. In this, however, he found masses of other rocks, very similar to those found in the Cambrians of Wales, and which he thinks must have come from beds of an intermediate age, like the Pebidian series in Wales, and which have either been completely denuded off here, or which must be present in some other area not far distant. These beds are, for the most part, nearly horizontal; but on the east side they dip slightly to the S.E., where they are succeeded unconformably by the quartzites of Crag Roy (these quartz rocks are also beautifully exhibited on Ben Eay, to the south of Loch Maree, and resting unconformably on the Cambrian rocks of the magnificent Torridon Mountains). Alternating with these rocks are some of the so-called fucoidal bands, the beds all dipping with a considerable inclination to the S.E. Upon the quartzites are seen the Limestone bands, occupying chiefly the sloping ground on the west side of Glyn Laggan. These are penetrated by a great mass of granitic rock, which produces here considerable contact-alteration, the limestone, however, at some distance from the mass being in a comparatively unaltered state. In all sections across Glyn Laggan hitherto described the mass of intrusive rock is made to penetrate along the bedding, and is supposed to separate the Limestone entirely from the upper series of rocks, the so-called Upper Gneiss, etc. The author, however, found another series of sandstones, calcareous grits, and blue flags beyond the main intrusive mass, and occupying a considerable portion of the gradually descending ground between the river and the heights on each side. These were also penetrated by another arm of the granite, but, as in the case of the limestone, with the sole result of altering them near the junction. Prof. Nicol places a fault at this point, and says that the fundamental gneiss is here brought up to give an appearance of overlying conformably the unaltered series. The author, however, holds, with Sir R. Murchison and Mr. Geikie, that the next is a younger series, and that it truly overlies the unaltered beds; but he entirely demurs to the view held by them that these should in any way be called gneiss rocks, or associated in any way with beds which have undergone the metamorphic change so characteristic of the pre-Cambrian rocks as known in this country, and which could only be induced, he believes, by great depression combined with heat, moisture, and pressure. On examination he found these upper beds everywhere unaltered, except near dykes, and the change there induced in them was that now well known as contact-alteration, and which is so entirely distinct from true metamorphism. These beds all dip to the S.E., and attain a thickness of several thousand feet. They are flag-like in character, are made up chiefly of fragmentary materials, and are occasionally even slightly calcareous. They are much like some of the Lower Silurian flags in Wales, and are in no degree more highly altered than the majority of those rocks, especially in the more disturbed districts. About 3 miles to the east of Glyn Laggan these beds die out, or at least are lost; and the Lewisian rocks, fundamental gneiss, hornblende-schists, and mica-schists, such as those described on the east of Loch Maree, again come to the surface, and the whole of the remainder of the section consists of these last rocks, the great mountains Ben Fyn, Mulart, and others being entirely made up of these rocks without a vestige of the unaltered beds reappearing there. Of the gneiss, hornblende-schists, and mica-schists which compose these mountains, it need only be said that, on comparison with others from Loch Maree, Gaerloch, etc., it is impossible to recognize any difference in them, the metamorphism being in each case identical in character, and garnets and other crystals occur in them in equal abundance. The strike in the beds at Ben Fyn he found also to be almost identical with those on the west coast, the dip being either to the N.E. or E., and seldom, if ever, south of that point. He also found these rocks, and with a similar strike, in the low ground in Glyn Docherty, near the road to Auchnasheen; and there the Silurian beds are seen resting unconformably upon them. From this the author believes that the Cambrian and Silurian beds are contained in a basin or depression formed of the older rocks, being, however, now altered in their dip and position by slight faults and some folding which has taken place since they were deposited.

3. "On the Triassic Rocks of Normandy and their Environments." By W. A. E. Ussher, Esq., F.G.S.

The author stated that his investigations were confined to the provinces of Calvados and La Manche, more especially the latter. Having briefly alluded to the physical areas of the Bocage and Cotentin, he proceeded to show that whilst the Secondary rocks were confined to the Cotentin, the presence of several Palæozoic inliers proved that they were of no great thickness. He then briefly described several sections illustrative of observations made by him in walking over the Triassic districts of Valognes, Montebourg, and Carentan, and of Bayeux in Calvados. The results arrived at (as far as possible, despite the presence of drift concealing the Trias almost everywhere) were that the Norman Trias is composed of gravel, sands and sandstones, and marls. The gravels replace and give place to sand and sandstone; but the position of the marls could only be distinctly ascertained near Carentan, where they underlie sandstones. The gravels and sands either directly underlie the infra-Lias, or are separated from it by a thin bed of marl. The Norman Trias can scarcely exceed 200 feet in thickness.

The author then briefly enumerated the Palæozoic rocks of the Bocage, and summed up the results of his investigations in the following conclusions:—

First, that the Triassic rocks of Normandy are the south-easterly prolongation of the Triassic area of Somerset and Devon.

Secondly, that Upper Keuper deposits are alone represented in Normandy.

Thirdly, that fragments of the Palæozoic rocks of what is now Normandy were never incorporated in the Triassic rocks of Devon.

Fourthly, that the constitution of the coasts of Normandy, Devon, and Cornwall is such as to justify a belief that varieties of Cambrian, Silurian, Devonian, and Granitic rocks formed the bed of the Triassic waters in the area now occupied by the English Channel, and that to these sources fragments foreign to the Devonshire soil found in the Triassic beds on the South-Devon coast are to be attributed.

4. "On Foyaite, an Elæolitic Syenite occurring in Portugal." By C. P. Sheibner, Esq., Ph.D., F.G.S. Communicated by Prof. T. M'Kenny Hughes, M.A., F.G.S.

The name foyaite is derived from Mount Foya, in the south of Portugal, where this rock occurs in the ancient province of Algarve, intrusive in Devonian grauwacke, where it forms two dome-shaped hills, the Foya and the Picota, rising respectively to 2968 feet and 2410 feet. The texture of the rock varies from fine to coarse-grained, and is sometimes porphyritic. An almost compact variety occurs cutting the coarser rock in dykes and veins. The coarser rock occurs mainly on the southern slopes, where, however, the adjoining grauwacke is less altered than elsewhere. The *massif* is also cut by intrusive veins of phonolite and basalt of Tertiary age. Much rock has probably been removed from the district by denudation.

Macroscopically foyaite consists of orthoclase, elæolite, and greenish hornblende. Orthoclase with imbedded elæolite occurs porphyritically. A lens shows titanite, biotite, magnetite, and pyrite to be accessories. Microscopically examined, the above constituents are seen to be present, and exhibit considerable variety in their mode of occurrence, together with nosean and sodalite as characteristic accessories, and occasional plagioclase (recognized as oligoclase), muscovite, hæmatite, and apatite. The elæolite is irregular in outline; nosean and sodalite are often associated with and imbedded in it. The latter minerals are associated and intergrown. Their mode of occurrence and the tests for their presence are described in detail. Hornblende and augite occur in foyaite in about equal quantities, associated and intergrown. These also are fully described, as well as the characteristics of the other accessories. Analyses of the elæolite and the foyaite are given. The author concludes by pointing out the close resemblance of the rock to ditroite, miascite, and certain syenites of Brevig and Cape Verd, stating that on this account there is no need of a special group of foyaites.

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## Natural History Society of Montreal.

At the last regular meeting of the Society for the season, held April 29th, notes by Principal Dawson were read on some recent discoveries in Canadian Geology and Palæontology. Some of these related to specimens collected by Lieut.-Col. Grant, of Hamilton, in the Niagara (Wenlock) formation. Among these are a great number of Graptolitic forms belonging to the genera *Deitzmania* and *Inocaulis*. Many new sponges of the Hexactinellid type, belonging to the genera *Astylospongia* and *Aulocopina*, and a large *Pterygotus*, "comparable in size with the great *Pterygotus Anglicus* of the Devonian of Scotland, though of much greater geological age. Some small species of *Pterygotus* have been described by Hall from the Waterlime formation of New York, and a fragment of an undescribed species has been found by the same palæontologist in the Clinton; but the present is, so far as known, the first example of a large and well-developed species of this genus from so old a formation. Col. Grant hopes to obtain additional remains. In the mean time the well-preserved maxilliped or ectognath exhibited, with rounded scaly basal part and narrow maxillary process with about 12 denticles and 3½ inches in length, is sufficient to indicate the existence of a new and large species, which may for the present be named *P. Canadensis*, and which was a Canadian predecessor of *P. Anglicus*."

Among recent facts relating to the geology of the Maritime Provinces of Canada, reference was made to a "new classification of the post-Pliocene deposits, and more especially the recognition of a layer between the typical Leda clay and the Saxicava sand corresponding to the Udevalla beds of the Swedish geologists, and which he proposed to name the Upper Leda clay. The Lower Leda clay contains only a slender fauna of highly arctic species, and corresponding to those found in the permanently ice-covered waters of Spitzbergen and Baffin's Bay. The Upper Leda clay holds a very rich fauna of Northern or Boreal type, but nearly related to that of Labrador at present."

Allusion was also made "to the greater certainty introduced into the classification of the older formations, which enabled equivalents to be recognized of the lower, middle and upper Cambrian of Europe, and which also showed that the older Cambrian rocks had been partially changed into gneiss and mica slate with andalusite, and that a large part of the Silurian period is represented in the Acadian provinces by volcanic rocks, quite dissimilar from the contemporaneous beds of the typical "New York Series," and more resembling the English Skiddaw and Borrowdale rocks, while they often have a very close resemblance to the older Huronian series which exists in their vicinity."

## CORRESPONDENCE.

### REPLY TO MR. USSHER AND H.E.H.

Sir,—I should not have troubled you with a reply to Mr. Ussher were it not called for to prevent misunderstanding. I know nothing of the age of the clay with flints, nor of the amount of denudation which has occurred since its formation. While in Devonshire I was under the impression that the gravels capping Blackdown extended (unchanged in character) some distance down the slopes into the valleys, and that the gravels with erratics on the summit of Little Haldon extended continuously some distance downward on both sides, and, on the east side, in patches as far as the sea-coast, in a manner to me inexplicable by subaërial re-distribution. I thought these gravels might possibly represent a part of the glacial drifts of the N.W. and E. of England, and I now think it possible that the older Devonshire gravels described by Mr. Ormerod, and lately in an able paper by Mr. H. B. Woodward (Q. J. G. S. vol. xxxii.), may have been accumulated during a part of the glacial period of the N.W. and E. of England. Mr. Woodward's sections very strikingly remind one of the mode of distribution of the glacial drift of the N.W. which more or less conforms to the slopes of the valleys and hills, and which is more a *wrapper* than a *leveller* of pre-existing surface-inequalities. Of the age of these older gravels relatively to the "Head" I cannot offer an opinion, but I have little doubt that a part of the glacial period of the N.W. is represented by the "Head" described by Mr. Pengelly, which covers or rather covered (for it has been very much tampered with by man) the Miocene lignite and clay of the Bovey basin. This "Head," which contained Arctic plants, and great numbers of undoubtedly ice-borne boulders (one of them 4 feet in average diameter (1867), has undergone an amount of fluviatile and estuarine denudation extremely insignificant when compared with the excavation of the Valley of the Exe or of the pre-Miocene Bovey valley. The fact that the "Head" covers the raised beaches of the S.W. of England does not prove its post-glacial age, because the date of these beaches relatively to those of the N.W., and indeed of the latter relatively to the glacial period or periods, is far from being certain. Mr. Godwin-Austen long ago regarded the former as, in one sense, pre-glacial. From the Land's

End to Weston-super-Mare the raised beaches are more or less covered with "Head," which often contains large and undoubtedly ice-borne boulders. Under the raised beaches of the W. coast of Cornwall and Devon, traces of an older deposit with ice-borne boulders may occasionally be seen, as I have been informed by Mr. Whitley of Truro, who has had very extensive opportunities of observing these phenomena. The raised beaches themselves sometimes contain very far transported erratics (washed out of an older glacial deposit ?).

In answer to H. E. H., it ought to be remembered that, in Sir H. de la Beche's day, the effects of glacial action were but little understood, and it is probable that he never saw sections of curved laminæ like those which of late years have been exposed by extensive quarrying and mining operations. I would refer H. E. H. to the very able defence of the glacial origin of persistently curved laminæ by Mr. Tiddeman in the Q. J. G. S. vol. xxviii. p. 480.

D. Mackintosh.

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ON THE FAUNA AND AGE OF THE SHINETON SHALES.

Sir,—I was glad to see in your April issue a letter by Dr. Linnarsson on the Trilobites of the Shineton Shales, as I am desirous that my conclusions should be tested in every possible way. I have carefully reviewed every detail to which he has suggested exception, and beg to submit a brief reply to his criticisms. His statements are the following.

1. *Conocoryphe monile* is more nearly related to Angelin's genus *Euloma* than to *Conocoryphe striata.*

To this I demur. *Euloma* is described by Angelin as *covered with a smooth crust,* and with *pleuræ acute, and bent back at the ends. C. monile* has a *granular surface* and *blunt pleuræ.* I submit that these are more important characters than the "strongly-lobed glabella and the dotted marginal furrow," in which *C. monile* is supposed to resemble *Euloma. C. striata* is larger than *C. monile,* has the glabella more conical, and with a third pair of side furrows, and has the frontal margin undotted, but on the whole the two species are of the same type.

2. *Lichapyge* is more closely allied to *Remopleurides* than to *Lichas.*

To this also I cannot agree. Dr. Linnarsson assumes that in my genus the "two hindermost thoracal segments" are united with the pygidium. If he were to examine my specimen, he would see that it consists of one undivided piece, and is therefore a pygidium only. This being so, it cannot be related to *Remopleurides.* It resembles *Lichas* in the number of segments (three), and in the shape of the pleuræ; but differs in the telson, which in *Lichas* ends in two denticles, while in *Lichapyge* it forms a broad sword-like blade with a central point.

3. *Platypeltis* is more nearly related to *Niobe* than to the typical *Asaphi.*

I myself called attention to this point on page 659.

4. *Conophrys* is probably the same as *Shumardia,* Billings, and as *Battus pusillus,* Sars.

I can say nothing to this, as I have been unable to obtain the published descriptions of the forms referred to.

Dr. Linnarsson seems to infer from the presence of *Conocoryphe monile* that the Shineton Shales are Upper Tremadoc. Even if his opinion of the affinities of this species were correct, we could not ignore the presence of two species of *Olenus*, of *Dictyonema sociale,* and of other Cambrian forms. Nor must we overlook the fact that in the Malvern district the Shales with *Dictyonema* immediately overlie the black *Olenus* Shales. I think that, with our present evidence, it will be safest to correlate the Shineton Shales with the Lower Tremadoc. I have just had the good fortune to detect them in force between the Longmynd and the Stiper Stones, the higher beds forming the base of the Stiper Stones escarpment. The dip is in the same direction as the overlying Arenigs; but towards the top of the series (where it grows more arenaceous and flaggy, as in the Shineton area) the beds are contorted and much jointed. I will not venture upon theory on the strength of one hour's work. It is gratifying to find my previous evidence from fossils so clearly confirmed, and to throw in the teeth of the unbelieving stratigraphists another proof that palæontology is not quite exploded.

WELLINGTON, SALOP, *May 9th*, 1878. CHARLES CALLAWAY.

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## *ORTHIS REDUX* IN MIDLAND BUNTER PEBBLES.

SIR,—In reply to the letter of Mr. J. H. Jennings in the May Number of the GEOL. MAG. it may interest him to know that the Rev. P. B. Brodie has drawn attention to the occurrence of fossiliferous pebbles in the drift near Warwick similar to those which occur at Budleigh Salterton, in the Quart. Journ. of the Geol. Soc. of London, vol. xxiii. (1867), p. 210.

The Drift of the Midland Counties is mainly composed of the redistributed Bunter Conglomerate, a formation which, as far as the pebbles which it contains are concerned, is lithologically and palæontologically identical with the Conglomerate of S. Devon. The stratigraphical position and relation of the two deposits, so far as I have examined them, in both districts appears much the same.

In the Museum of the Midland Institute is an extensive series of Bunter material, collected from the gravel around Birmingham, which I presented in 1872 to the Birmingham Naturalists' Society, as well as of specimens for purposes of comparison from the Bunter Conglomerate itself. In 1875 I gave a beautiful series of fossiliferous pebbles to the Jermyn Street Museum, also from the Birmingham Drift. *Orthis redux* is, as at Budleigh, one of the commonest fossils. SPENCER GEORGE PERCEVAL.

HENBURY, BRISTOL, *May* 11, 1878.

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## WHAT IS AN ERRATIC?

SIR,—Under this title, in your April Number for the current year, my esteemed colleague, Mr. Wynne, argues that I am wrong in restricting the term to fragments which have been transported by ice, and maintains that it is equally applicable to pebbles and boulders, instancing the flints on the Irish coast and the constituents of the Chesil Bank as *erratics*, in his sense of the word. If the bulk of geologists agree with Mr. Wynne in this, I confess I shall feel surprised. Mr. Wynne also disputes certain views of mine touching minor details of geology in the Salt Range, but it is not my intention to notice these, as, the ground being unknown to the bulk of your readers, the discussion would be both tedious and unprofitable.

In justice to myself, however, I cannot permit the second paragraph of Mr. Wynne's letter to pass unchallenged, as it contains a complete and incomprehensible misapprehension of my meaning. The passage runs thus: "In these remarks,[1] Mr. Theobald restricts and applies the term '*Erratics*' exclusively to certain blocks supposed to have been ice-transported, advocating the idea also (*vide* foot-note) that the word is *only applicable in describing recent phases of geology*."

Of course I neither said nor meant any such thing as the extraordinary statement I have italicised above. What I *did* say was: "Under these circumstances, therefore, I do not think that these red granite boulders can be termed '*erratics*,' unless we fall back on the hypothesis that all of them have been erratics during a former and wholly different phase of geological life than that which we at present have to describe and deal with." (*l.c.*)

Now I deny that my words can fairly be twisted so as to yield the extraordinary sense, or rather nonsense, which Mr. Wynne attributes to me; and had my MS. not received some mutilation (unknown to me) in passing through the press in Calcutta, this misapprehension of my colleague could hardly have happened. I originally wrote some such explanatory sentence as the following: "Unless on the principle of once a parson always a parson, we hold that once an erratic, always an erratic." Of course the Chesil Bank boulders may at one time or another have been erratics; but *unless on the principle of the above proverb*, they can, I think, be termed so no longer.

As this is the exact opposite of the ridiculous view Mr. Wynne fathers on me, I wish to repudiate the mistake in the same pages wherein it appears, to my great discredit if uncontradicted.

MARREE, PANJAB, *May 13th*, 1878. W. THEOBALD.

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WHAT IS AN ERRATIC?

SIR,—I should have called attention in the second paragraph of my letter, in your April Number, 1878, p. 185, to the passage in my friend Mr. Theobald's remarks which reads thus: "Under the head 'Erratics' . . . . . my colleague describes others, which are not only, in my opinion, not 'erratics' at all, but belong to diverse geological epochs."

This, together with his footnote, to which I referred, left the impression that, according to him, "erratics" must belong to but one and that a recent geological epoch. A. B. WYNNE.

[1] Records of the Geological Survey of India, vol. x. part iv. p. 223.

## PHYSICAL GEOLOGY OF THE PUNJÁB.

Sir,—Will you allow me to make a few corrections in your abstract of my short paper to the Geological Society (Geol. Mag. Dec. II. Vol. V., No. IV., April, 1878, p. 181.)

Line 1 *for* "accession" *read* "accessible."
,, 12 *for* "on limestones" *read* "are limestones."
,, 14 *for* "Lei Bau" *read* "Sirban."
,, 26 *between* when *and* present *insert* "both are."
,, 28 *for* "further east a" *read* "further east, in the Salt Range a."

A. B. Wynne.

## SUBGLACIAL ORIGIN OF TILL.

Sir,—Mr. Geikie writes you that "I quietly ignore all the *positive* evidence " which has been adduced in proof of the subglacier origin and accumulation of the chalky Till of Suffolk."

I know of no such *positive* evidence.

*Per contra.* Why does Mr. Geikie so quietly ignore the *positive* evidence of marine conditions afforded by the thread of sand, packed with the remains of marine mollusca with valves adherent, which was discovered by Prof. T. M. Hughes and Mr. L. Lyell in the midst of the chalky basement clay of Holderness, which is similar in character and structure to the chalky clay of Suffolk?

S. V. Wood, Jun.

## ERRATUM.

Sir,—Not having had the opportunity of examining the drawings of Plate VIII., in the June Number, before the stone was etched, allow me to call attention to some points in which they are defective. In Fig. 1 the oblique foraminal notches are not defined, these are an important character, and are clearly shown upon the fossil; again, Fig. 2 does not give the entire outline of the mandibular ramus, which is well represented upon one of the blocks, inasmuch as the artist has omitted in his drawing the imperfect angular and articular bones preserved upon it, and it is consequently half an inch too short. The enamel of the teeth is finely plicated on the cutting edges, but the teeth are not crenulated, as the drawing of the plications on the enlarged Figure 2 *b* might suggest. Finally, in "Explanation of Plate," Fig. 2*b*, for *inner* read *antero-posterior*.

Wm. Davies.

Erratum.—We are are requested to make the following correction of the notice of Prof. M'Coy's "Victorian Organic Remains" (Decade V.) given in the June Number, see p. 284, lines 5 and 6 from top:—

Substitute *for* "whether the supposed Mesozoic genus *Belemnites* may," etc., "whether the Mesozoic genus *Belemnites* supposed to occur in the Australian Tertiaries may," etc.

# OBITUARY.

## REV. W. B. CLARKE, M.A., F.R.S., F.G.S.

We are sorry to learn the death of this distinguished Australian geologist at Sydney, New South Wales, by telegram, on June 17th. —*Nature.* (We hope to give a full notice of Mr. Clarke next month.)

## RICHARD DAINTREE, C.M.G., F.G.S.

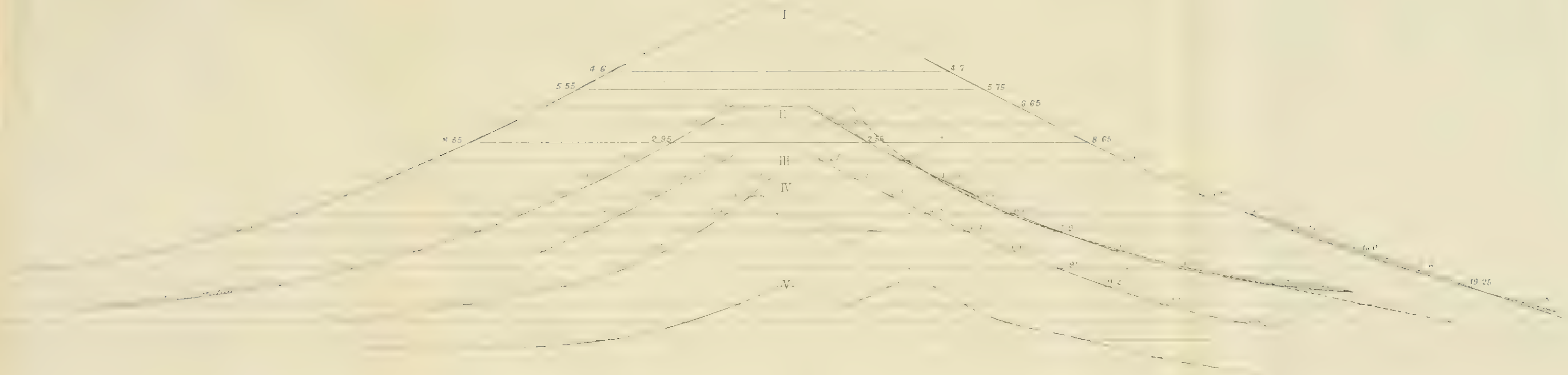
The *Standard,* June 24th, 1878, announces the death of Mr. Richard Daintree (late Agent General for Queensland) on the 20th June, at his residence, Holyrood House, Beckenham, Kent. Mr. Daintree's death will be deeply regretted by a wide circle of geological friends. We shall give a notice of Mr. Daintree's geological works next month.

## PROFESSOR C. F. HARTT.

The mail from New York brings us the sad news of the death of Prof. Charles Frederick Hartt, of Cornell University. He died on the 19th of March last of yellow fever at Rio Janeiro. Prof. Hartt at the time of his death was in charge of the Brazilian Geological Survey; he was a native of Frederickton, New Brunswick, having been born there in 1840, but it was in Nova Scotia where he first followed geological pursuits. After having been a student under Prof. Agassiz from 1862 to 1865, he accompanied that gentleman to Brazil with the Thayer Expedition in the latter year. The account of this and a later journey he embodied in "Scientific Results of a Journey in Brazil—Geology and Physical Geography of Brazil," Boston, 1870. Prof. Hartt was a diligent student of Indian languages and folk-lore, and not long since published at Rio a brochure on the "Hare and Tortoise Myths of the Amazonian Indians."

## ALEXANDER HEATHERINGTON, F.G.S., ETC.

It is with regret that we record the death of Alexander Heatherington, Esq., F.G.S., late of Halifax, Nova Scotia. He died at Toronto on the 8th of March last, of pleurisy. The province of Nova Scotia owes him a debt of gratitude for his persistent efforts to promote her progress, and bring her to the front as one of the first gold-producing countries of the world. He was a clever statistician and the author of "A Practical Guide for Tourists, Miners, Investors, and all persons interested in the Gold Fields of Nova Scotia," and "Mining Industries of Nova Scotia, a Review of the Gold Field from 1860" to 1873, 1875, etc. He was editor and proprietor of the "Mining Gazette," published at Halifax, Nova Scotia, a few years ago.




Profile of Volcanos traced from Photographs.

*Measurements in Millimetres*

*To illustrate Prof John Milne's Paper.*

J Milne del. W West & Co. imp.

THE

# GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. V.

No. VIII.—AUGUST, 1878.

## ORIGINAL ARTICLES.

### I.—On the Form of Volcanos.

By Professor John Milne, F.G.S.,

Imperial College of Engineering, Yedo, Japan.

(PLATE IX.)

FROM the short notices which are to be found about volcanos in treatises on geology, we might often be led into the belief that they were structures so regular in contour that their form was indicative of their nature. In certain cases this appears to be so remarkably true, that I wish to add a few observations to those which have already been written upon the subject. In other cases, however, the form of a volcano does not appear to have any characteristics which distinguish it from other mountains, as will be seen by glancing through the series of views given by Humboldt of the volcanos of South America. The mountains in Iceland are also very rough. When travelling in that country, where I saw and ascended many volcanos, I do not remember that there was anything about their shape more than their steepness and general ruggedness which particularly attracted my attention.[1] The wilderness of form presented to us by such mountains as these is so evidently the combined effect of many and varied causes, that it would be vain to seek a simple explanation for the formation of the whole.

With other volcanos which have been built up according to the formula of our text-books, that is, by the ejection and accumulation of material round a central vent, the case is different. I will endeavour to show that such mountains which, for the want of a more accurate term, have been called conical, have a particular kind of regularity which does not appear to have been hitherto noticed. Conversely, I wish also to point out, that if this particular form is observed, that from it, not only is it possible to state how the mountain has been built up, but also from any variations in this form to determine the presence and dimensions of an internal core. For these purposes I shall take the mountains which I have had the opportunity of observing since my residence in Japan. The first point to be observed about many of these mountains is the regularity

[1] This, however, is a statement made from memory, for shortly after my return to England, my Icelandic sketches and note-books were unfortunately lost.

of their contour, and secondly the fact that these contours appear to be similar. Pre-eminent amongst the regularly formed volcanos of Japan with which I am acquainted I may mention Fusiyama, 12,365 feet, near Yokohama; Ganjosan, 7000 feet, near Morioka; Chokaisan, 6000 feet, between Niigata and Akita; Twakisan, 5000 feet, near Awomori; and Kumagatake, 2700 feet, near Hakodate.

If we look at the profile of these mountains near their summits, we might be inclined to call them conical; but if we look at them as a whole, as we descend we see this upper cone expanding and sweeping outwards, forming a graceful curve. The causes which might produce or subsequently affect this form may be summed up as follows.

1. The position of the crater. If this is central and remains in that position during successive eruptions, we may expect the mountain to be regular in form.

2. If the eruptions of a mountain are irregular in their action and character, the above regularity may be destroyed. Thus by paroxysmal outbursts portions of a cone might be removed,—if lava is erupted at one time and not at another, or if it accumulates on one side of the mountain more than on another, these are all causes which would seriously interfere with any regularity of contour.

3. Any outbursts on the side of a mountain, or formation of parasitic craters, will also tend in the same direction.

4. Even if the crater should be central, but the direction in which the lapilli and other materials were projected should be towards one side more than another, as I sometimes observed was the case at the eruption of Oshima in 1877, the regularity of the piling up will also be interfered with.

5. The direction of the wind during an eruption will also influence the shape of a mountain. On the Yedo side of Fusiyama the slope is less than upon the opposite side. This I believe is in part due to the wind, which at the time of the last eruption of that mountain, in 1707, was blowing in the direction of Yedo.

6. The nature, that is, the size, the specific gravity, the porosity, etc., of the materials thrown out will during the actual accumulation and subsequent consolidation give a character to the curve of the slope.

7. Lastly, we have the effects of denudation continually drawing material to lower levels and sculpturing and modifying the original contours. As this action will generally take place more or less uniformly on all sides of a mountain, it will be a cause tending not so much to destroy the regularity of a volcano as to alter the character of its slope.

When considering the various causes which may produce denudation, we must remember that there generally will have been more action near the summit of a mountain than near the base. Thus, for example, more water falls at the top of a mountain than below, and therefore the little streamlets which cause disintegration will be more active at the top of a mountain than at the bottom—the activity diminishing gradually towards the base. One of the tendencies of such an action is to make a mountain steeper near the top than lower down, an appearance which will be again referred to.

If we wish to discover an explanation for the differences which exist between the characters of the volcanos of two countries like Iceland and Japan, it is not to the effects of denudation that we ought to look, for denudation in the case of the volcanos of these two countries, which are either now in action or else have been so within periods which are almost historical, might, I think, be taken as being equivalent to each other. We must rather look to the nature and the products of the eruptions. In Iceland I suspect that the outbursts have been more paroxysmal, whilst the number and extent of lava flows are perhaps unrivalled. These causes have given a ragged wildness to the country and its mountains. In Japan, however, lava streams, although existing, are by no means numerous, and the mountains, which far exceed the height of those in Iceland, must, generally speaking, have grown gently upwards like a heap formed by sand falling through a funnel upon a level floor. In consequence of this it will be shown that they have in many cases assumed a form as symmetrical as any which would be expected in an engineering earthwork.

*Slopes of Volcanos.*—If we look at the cuttings along a railway, we shall see that their slope varies with the material through which they are run. When the material is loose and friable, the slope is more gentle than when it is tenacious and has much friction amongst its particles; for example:

| | | | | | | |
|---|---|---|---|---|---|---|
| For compound earth | the natural | slope is | | ..... | ..... | 50°. |
| ,, gravel | ,, | ,, | ,, | ..... | ..... | 40°. |
| ,, dry sand | ,, | ,, | ,, | ..... | ..... | 38°. |
| ,, sand | ,, | ,, | ,, | ..... | ..... | 22°. |
| ,, wet clay | ,, | ,, | ,, | ..... | ..... | 16°. |

When climbing up the sides of volcanos I have invariably observed that the materials resting upon any particular slope are uniform in size; and if we take a piece of lava or lapilli which is larger than the other particles, and throw it upon such a slope, we see it commence to roll rather than remain at rest. From this it appears that we ought generally to find the large pieces of material which are ejected from a volcano upon the more gentle slopes near to the base of the mountain. The reason of this evidently lies in the fact that friction depends on surface, and weight depends on volume, and that as bodies are made smaller and smaller the ratio of their surface to their volume increases more and more.

Should we be desirous of making any investigation respecting the slopes upon the face of a long escarpment, or the face of a broad chain of mountains, the theory and rules given by Rankine in his Investigations about Earthworks might be applied. In a volcano or solitary mountain, such as those which are now referred to, the conditions would be somewhat different, as we have to consider the stability of a mass of material with a variable radius, whilst in the former case the radius might be regarded as being infinitely long. As there does not appear to be any formula given in books on engineering, respecting the slope or form which would be assumed by a heap of loose dirt, an engineering friend has shown me that it follows from Rankine's theory, notwithstanding that the same is incomplete, that the surface is that which would be produced by a simple logarithmic curve revolving about an axis,—consequently such a heap would have a slope diminishing from the top to the bottom. Looking over my note-books, amongst the steepest slopes which I have observed upon the sides of volcanos in Japan, I may mention the following: Fusiyama, 30°; Asamayama, 28°; Ganjosan, 31°; Twakisan, 30°; and Kumagatake, 40°. The first four of these are outside slopes taken near the top of the mountain. The last observation was made upon a slope of angular blocks of stone inside an old crater.

Mr. Scrope gives the slopes of volcanos as being from 20° to 35°, towards the base diminishing to 10°, and gradually ultimately to horizontality. However, whilst fully recognizing the nature of the true slope of a volcano, the sketches which illustrate works treating of this subject are, so far as can be judged by rough measurements, somewhat misleading. For example, to quote from the pictures in the works of no less a person than the great Humboldt, "Umrisse von Vulkanen aus den Cordilleren von Quito und Mexico," I find that, by rough measurement, the slopes of several volcanos must be as follows: — Cayambe Uren, 18,170ft., about 53°; Elcorazon, 14,820ft., 53° to 69°; Chimborazo, 17,712ft., 55°; and Ilinissa, 16,362ft., 55°. Whether these Matterhorn-like inclinations really represent reality or not, I do not know, but I should be inclined to think that artistic feeling may have caused them to have been unintentionally augmented.

*Form of Volcanos.*—The general form of a volcano has already been suggested whilst speaking of the inclination. To quote more fully from Mr. Scrope, he says, "It should be remarked, however, that the dykes being more numcrous near the central vent, their aggregate effect in elevating these beds will be greatest *there*, and give them a steeper elevation near the summit than lower down the flanks of the mountain. This is one cause (but by no means the principal one) of the angle of the slope of the higher beds, and of the outer slope likewise, usually ranging from 20° to 35°; while towards the base it diminishes to 10°, and graduates ultimately to horizontality. The more influential causes of this general result are (as will shortly be shown), the frequency of lateral eruptions on the lower slopes of every volcanic mountain, loading them with parasitic cones and floods of lava, and the abundance of fragmentary matter carried down the heights by rain and floods—all combining to enlarge the base."[1] Whilst fully agreeing with the form which is here described, the causes which are indicated as having been the principal ones in the production of such a mountain form, although no doubt, influential, are, I should think, by no means the principal ones. Of the greater number of volcanos which I have seen in Japan, the only method which I have had of obtaining their general form and curvatures has been by sketching. Of two of them,

[1] Scrope, Volcanos, p. 167.

Fusiyama and Kumagatake, I have been able to obtain large photographs,—of the former no less than thirty different views. As these pictures, which have a slight distortion due to perspective, were the best representation of the true form of a volcano which I could obtain, it has been assumed that they are correct, and they have been used in determining the shape of the mountain in the following manner. To investigate the form of these mountains it was first required to find an axis for them, which was attempted by drawing verticals through some objects, and their reflections, which happened to have been photographed in the foreground of one of the pictures. Afterwards it was found better to make tracings of the photographs, which were doubled until a greater portion of the profiles coincided, and then to take the crease in the paper as being the median line and axis.

Enlarged drawings made by a pantograph were also used, but these were found not to be so convenient as the tracings from the actual photographs which are represented on the accompanying sketch. In the cases which are represented, with the exception of one or two slight excrescences which are shown by shading, the profiles are coincident with a free curve. Whilst looking at these profiles it must be remembered that any apparent differences in curvature, which may be observed, are due to the fact that one profile may represent only the upper portion of a mountain, whilst another may give a view from the summit to the base. Thus, for example, profile No. I. only shows the upper portion of profile No. II. The next thing which was done was to draw a series of ordinates at $5^{mm}$ apart, the length of each of which $r$, was accurately measured, and may be seen in the first columns of the following tables. In the second column, the sum of each successive pair of these ordinates $R$ is given, and in the third column their differences $dr$.

Now it is found, as will be seen by looking at the fourth column, that $\frac{R}{dr}$ is equal to a number which is nearly constant, which is the peculiarity of a Logarithmic Curve.

Profile No. I. Plate IX.
Fusiyama, from near Marajama. S.W. side.

Left Side.

| r | R | dr | $\frac{R}{dr}$ |
|---|---|---|---|
| 4·60 | | | |
| | 10·15 | ·95 | 10·67 |
| 5·55 | | | |
| | 11·80 | ·70 | 16·85 |
| 6·25 | | | |
| | 13·75 | 1·25 | 11·00 |
| 7·50 | | | |
| | 16·05 | 1·05 | 15·28 |
| 8·55 | | | |
| | 18·15 | 1·05 | 17·28 |
| 9·60 | | | |
| | 20·50 | 1·30 | 15·76 |
| 10·90 | | | |
| | 23·10 | 1·30 | 17·76 |
| 12·20 | | | |
| | 25·80 | 1·40 | 18·42 |
| 13·60 | | | |
| | 28·95 | 1·75 | 16·54 |
| 15·35 | | | |
| | 32·85 | 2·15 | 15·27 |
| 17·50 | | | |
| | 38·20 | 3·20 | 11·94 |
| 20·70 | | | |

Right Side.

| r | R | dr | $\frac{R}{dr}$ |
|---|---|---|---|
| 4·70 | | | |
| | 10·45 | ·05 | 20·9 |
| 5·75 | | | |
| | 12·40 | ·90 | 13·7 |
| 6·65 | | | |
| | 14·35 | 1·05 | 13·6 |
| 7·70 | | | |
| | 16·35 | ·95 | 17·21 |
| 8·65 | | | |
| | 18·40 | 1·10 | 16·72 |
| 9·75 | | | |
| | 20·55 | 1·05 | 19·57 |
| 10·80 | | | |
| | 22·75 | 1·15 | 19·78 |
| 11·95 | | | |
| | 25·15 | 1·25 | 20·12 |
| 13·20 | | | |
| | 27·75 | 1·35 | 20·55 |
| 14·55 | | | |
| | 30·55 | 1·45 | 21·06 |
| 16·00 | | | |
| | 33·60 | 1·60 | 21·00 |
| 17·60 | | | |
| | 36·85 | 1·65 | 22·33 |
| 19·25 | | | |
| | 40·25 | 1·75 | 22·00 |
| 21·00 | | | |

PROFILE NO. II. Plate IX.
Fusiyama, from near Hitoana. West side.

LEFT SIDE.

| r | R | dr | $\frac{R}{dr}$ |
|---|---|---|---|
| 1·30 | 3·35 | ·75 | 4·46 |
| 2·05 | 5·00 | ·90 | 5·55 |
| 2·95 | 6·80 | ·90 | 7·55 |
| 3·85 | 8·70 | 1·00 | 8·70 |
| 4·85 | 10·70 | 1·00 | 10·70 |
| 5·85 | 12·85 | 1·15 | 11·17 |
| 7·00 | 15·40 | 1·40 | 10·71 |
| 8·40 | 18·50 | 1·70 | 10·88 |
| 10·10 | 22·40 | 2·20 | 10·18 |
| 12·30 | 26·50 | 1·90 | 13·94 |
| 14·20 | | | |

RIGHT SIDE.

| r | R | dr | $\frac{R}{dr}$ |
|---|---|---|---|
| 1·75 | 4·30 | ·80 | 5·37 |
| 2·55 | 6·05 | ·95 | 6·36 |
| 3·50 | 8·05 | 1·05 | 7·66 |
| 4·55 | 10·10 | 1·00 | 10·10 |
| 5·55 | 12·20 | 1·10 | 11·10 |
| 6·65 | 14·55 | 1·25 | 11·67 |
| 7·90 | 17·20 | 1·40 | 11·28 |
| 9·30 | 20·55 | 1·95 | 10·50 |
| 11·25 | 25·05 | 2·55 | 9·807 |
| 13·80 | | | |

PROFILE NO. II. *continued.*

Profile No. II., with other ordinates, gave upon the left side the following :—

| r | R | dr | $\frac{R}{dr}$ |
|---|---|---|---|
| 2·000 | 4·825 | ·825 | 5·8 |
| 2·825 | 6·600 | ·950 | 6·9 |
| 3·775 | 8·525 | ·975 | 8·7 |
| 4·750 | 10·550 | 1·050 | 10·0 |
| 5·800 | 12·675 | 1·075 | 11·7 |
| 6·875 | 15·075 | 1·325 | 11·3 |
| 8·200 | 17·900 | 1·500 | 11·9 |
| 9·700 | 21·300 | 1·900 | 11·7 |
| 11·600 | 25·600 | 2·400 | 10·6 |
| 14·000 | | | |

I omit the right side of the profile because on that side there is a distortion due to the last eruption in 1707, which was a lateral one.

PROFILE NO. III. Plate IX.
Fusiyama, from Suyama and Gotemba. South-east side.

LEFT SIDE.

| r | R | dr | $\frac{R}{dr}$ |
|---|---|---|---|
| 1·45 | 3·85 | ·95 | 4·052 |
| 2·40 | 5·70 | ·90 | 6·333 |
| 3·30 | 7·56 | ·95 | 7·842 |
| 4·25 | 9·60 | ·90 | 10·660 |
| 5·35 | 11·85 | 1·15 | 10·300 |
| 6·50 | | | |

RIGHT SIDE.

| r | R | dr | $\frac{R}{dr}$ |
|---|---|---|---|
| 1·25 | 3·55 | 1·05 | 3·03 |
| 2·30 | 5·60 | 1·00 | 5·60 |
| 3·30 | 7·60 | 1·00 | 7·60 |
| 4·30 | 9·70 | 1·10 | 8·81 |
| 5·40 | 12·05 | 1·25 | 9·63 |
| 6·65 | 14·60 | 1·30 | 11·23 |
| 7·95 | 17·10 | 1·35 | 12·66 |
| 9·20 | 20·00 | 1·60 | 12·50 |
| 10·80 | 24·00 | 1·40 | 10·00 |
| 13·20 | | | |

PROFILE NO. IV. Plate IX.
Kumagatake, as seen when approached from Hakodate.

LEFT SIDE.

| r | R | dr | $\frac{R}{dr}$ |
|---|---|---|---|
| 0·15 | 0·25 | 0·25 | 5 |
| 0·70 | 1·50 | 1·30 | 1·15 |
| 1·40 | 3·55 | ·75 | 4·73 |
| 2·15 | 5·20 | ·90 | 5·78 |
| 3·05 | 7·30 | 1·20 | 6·08 |
| 4·25 | 10·05 | 1·55 | 6·48 |
| 5·80 | 14·40 | 2·80 | 5·14 |
| 8·60 | 20·00 | 2·80 | 7·14 |
| 11·40 | | | |

The right side is left out, because it is so very irregular.

No. V. is not calculated, because it is probable that the only photograph which I have may have been taken from a picture. It is, however, useful as showing, as compared with the others which are drawn, a similarity in curvature.

Considering that these investigations have been open to so many errors, the picture being a perspective view, it being small and difficult to make measurements upon, there being no accurate method for obtaining a true axis, there being many small irregularities in the mountain itself,—the fact that the calculations made from different pictures should all so closely approximate to each other is evidence, I think, sufficiently converging for us to accept the result towards which it points.

That this result should agree with that obtained for the stability of a self-supporting mass of loose materials is very striking, and seems to show, notwithstanding its roughness and the observations to which it has been applied, an invariable concurrence.

This being the case, I think we are justified in regarding mountains, similar to those about which I am now writing, as having a form mainly due to the simple piling up of material, and not as cones which have been subsequently modified by a number of secondary causes, such as are advocated in treatises on Physical Geology and Volcanos.

*Probable Existence of an Internal Core.*—Observing that the slight discrepancies which do exist in the values of $\frac{\mathrm{R}}{\mathrm{dr}}$ are due to variations in the curvature near the top, and at the base of the mountain it was suggested that these might not only be due to external modifying and sculpturing actions, like those pointed out by Mr. Scrope, but also, perhaps, to the action of an internal core. If we pour sand upon a table, it ought to form a heap, with sides like those of a Japanese volcano; but if we first place a small box on the table, and pour sand on the top of it until it is buried, the shape of the heap will be considerably altered. If, instead of a box and sand, we take a mountain like Fusiyama, and imagine it to have a core which is tolerably flat, such as we might have expected from the more modest of the advocates of an elevation theory, the result would be that the present base of the mountain would be considerably contracted, because in this case the core is capable of resisting a greater pressure than an equal bulk of cinders could resist. Above the core the curve would be logarithmic, from which we may conclude that if any core exists in the mountains about which I have been writing, it is probably below the lowest line at which measurements have been made. To enter fully into the effect which a core would produce upon the external form of a mountain, is a calculation into which friction would enter as an important factor.

If, from the shape of any given mountain, it were supposed that it had been built up round a more or less cylindrical core, it would be interesting to calculate the diameter of this core for various heights. This also can be shown to be logarithmic in form.

*Building up of a Volcanic Mountain.*—The eruption at the island of Oshima, of which, in 1877, I was a close spectator, commenced by the throwing up of ashes from a fissure which had for several years previously only given vent to steam. At the time of my visit a quantity of these had accumulated to form a heap of a certain height. The form of this heap was to all appearances similar to that of the larger mountains. For this heap to increase in height, so long as the plane on which it rested was approximately level, it was necessary that it should also increase the diameter of its base. Now, if the sides of a volcanic mountain have slopes which are always logarithmic curves, and if we assume that the area of the top is always some fraction of the height, the relative rates at which the height and the diameter of the base increase can be easily calculated,—and if we have given the height of a mountain, we shall, under the given circumstances, be able to determine the diameter of its base.

The eruption at Oshima has now ceased, and the materials which have been ejected may be regarded as the nucleus of a small mountain. By such causes as the action of its own weight, infiltration, etc., this mass is now gradually becoming consolidated. As this embryonic mountain is of the best possible shape to resist the effects of denudation and weather generally, from wearing much from its sides, this consolidation will leave it in a form not very much unlike that in which it was first raised. Should a second eruption take place from or near the old crater, it will have to pile material on this hardened nucleus, which, being stronger than a mass of loose ashes, will act like a box beneath a heap of loose sand, rendering the mountain generally steeper.

We have evidently here in certain cases a rough test as to whether any mountain has been produced by one or more large eruptions, and at the same time an insight into the probable method by which many volcanic mountains have been raised.

Where there have been many overflows of lava, these may have consolidated like ribs or buttresses on the sides, and have tended to make the nucleus still stronger, and, therefore, prepared after the next eruption to support material at a still steeper angle.

As the mountain increases in height, its weight, as pointed out by Mr. Mallet, probably produces a depression in the base on which it rests, this being greatest under the apex of the mountain, where the pressure is greatest. The ultimate result of all this will be that the mountain will tend to rest in a saucer-shaped hollow, and to have its lower beds dipping radially towards a centre. If this action should have taken place in any mountain, it might at first sight be considered as influencing the external form of the mountain, and consequently any deductions which have been drawn from such a form. However, we must remember that this sinking will, as compared with the mass of the mountain, be small, and, also, it will be gradual, so that, without appealing to calculations, I think it will be admitted that the accumulation of material will more than counteract such an action. Even should there be a sudden collapse beneath a mountain tending to produce any inequalities on its external surface, these inequalities will represent material in an unstable position, which will gradually give way before the tendency which the mountain will always have, namely, to assume that position in which the materials are best arranged to afford to each other a mutual support, and this position appears to be that of the logarithmic curve which has been described.

We have not yet considered that these mountains have to support anything but their own weight, but as Rankine has shown that the logarithmic form is the best for revetement walls, or walls of reservoirs, etc., without going into calculations, it will be evident that these regular volcanos are also strong enough to support the pressure of a column of lava of their own height.

In conclusion, I may remark that just as it is possible that the fiery mountains and earthquakes of Japan impressed its inhabitants with wonder and superstition, so the beautiful forms of the volcanos may have been the first suggestions for the curvatures we see upon the roofs of houses, and for the massive walls which bound the moats and support the embankments of all the castle towns. How far this may be true, I do not know, but certainly the form which has of late years been shown the most stable for such structures, is one which in Japan has reached its millennium.

### EXPLANATION OF PLATE IX.

Profiles of Volcanos traced from Photographs.

No. I. Upper portion of Fusiyama, taken from near Marayama, S.W. side.
No. II. Fusiyama, from near Hitoana, West side.
No. III. Fusiyama, from Suyama and Gotemba, S.E. side.
No. IV. Kumagatake, as seen from near Hakodate.
No. V. Monte Somma and Vesuvius.

The shaded portions show irregularities in the curvature of the mountains. These, it will be observed, are very small

The broken line - - - - on the right of No. II. is a logarithmic curve drawn for purposes of comparison.

It suggests that No. II. was once logarithmic, but the upper portions of the mountain have been washed to the bottom to render the mountain less steep both above and below.

It also might indicate that the phenomena, spoken of by Mr. Mallet, had taken place, namely, that the weight of the central portion of the mountain had caused an elevation round the base.

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## II.—Somersetshire Coal-measures.

By H. E. Hippisley, M.A., C.E.

It will probably be conceded, by those who have studied the Somersetshire portion of the British Coal-field, that the correlation of the various parts of it is not, at the present time, so perfect that any attempts to improve it are entirely uncalled for. The following conjectures [1] as to whether some of the facts relied on as proving the commonly-accepted theory of the structure of the Somersetshire Coal-measures, and their general correlation with those in Gloucestershire, may not possibly admit of an interpretation differing from that usually assigned to them; are put forward in the hopes of indicating a line of research which may eventually, when modified by the results of further investigations, lead to a

[1] Being a brief summary of an unpublished paper on the subject.

solution of some of the numerous difficulties at present standing in the way of a satisfactory understanding of this extremely complicated district.

The commonly accepted structure in Somersetshire is taken to be as follows—in descending order :—

1. The Radstock measures, supposed to be wanting in Gloucestershire and stated to have been removed by denudation there.
2. Beds of red shale, traces of which are supposed to exist in Gloucestershire near the top of the Coal-measures there.
3. Farrington measures, supposed equivalent to the Gloucestershire upper series measures.
4. Pennant.
5. Lower series Coal-measures.
6. Millstone Grit.
7. Carboniferous Limestone.

All, of course, more or less disturbed by faults, but still in the above order; and this general relation of the Coal-measures in Somersetshire to those in Gloucestershire is supposed to be thoroughly well established.

It may be as well to allude briefly to some of the causes which make these Coal-measures peculiarly difficult to study in such a manner as to be certain that the results arrived at are free from error.

About five-sixths of the Bristol Coal-field are concealed by newer formations, rendering it impossible to trace the measures, or the position of the numerous faults of an older date than these newer formations, on the surface; the sole information obtainable, when the Coal-measures are not exposed, being from the workings at the different collieries.

These workings at different places have in many cases not been connected by accurate instrumental measurements, but often only in a vague and general way, and by assuming perfect regularity in the strata between the separate workings, when perhaps the very contrary may be the case.

Absence of records showing the full details of pit sections; the only information obtainable now, concerning many of the older sinkings, being the simple intervals between the seams. Also, faults cut through in the shafts do not always appear in the sections.

Correlation of the seams has occasionally proceeded in rather a haphazard manner, the seams being named first, sometimes without nearly sufficient evidence as to their identity, and then the names traced from one colliery to another as if the correlation were undoubtedly correct.

The correlation would have been much more reliable if the full detailed sections had been taken into account instead of merely fancied resemblances and qualities and thicknesses of the coals alone, all often extremely variable in comparatively short distances.

The faults of the district are extremely numerous, those shown on the Geological Survey being, although by no means few, only a portion of them, complicated, and with throws often very considerable, and where the throw of a fault is, as usual, calculated by the amount of displacement of a seam bearing the same name on each side of the fault, it results that if the seams should happen to be wrongly correlated, the throw of the fault may be very different to that which it is supposed to amount to.

Uncertainties as to whether certain Coal-measure sandstones are true Pennant, or should be taken as belonging to other geological horizons.

Contemporaneous denudation having removed certain strata and seams of coal, possibly not long after they were formed, the seams being sometimes replaced by beds of sand, etc.

There are many other difficulties in the way of satisfactory correlation, on which it is not necessary to dwell further, as they soon present themselves only too plentifully to any investigator of the subject. It may be briefly stated that the structure of the district, generally, is so much the reverse of regular, that instances can be pointed out in which the strata met with at the bottom of a tolerably deep shaft are the same that had already been passed through at the top thereof; and in further illustration of the amount of dislocation the district has suffered, allusion may be made to a locality where, by simply crossing the breadth of a turnpike road, Old Red Sandstone may be found on one side, and Coal-measures on the other; the Lower Limestone Shales, Carboniferous Limestone and Millstone Grit (present in force near at hand) being entirely absent, to say nothing of possibly part of the Old Red and part of the Coal-measures being likewise cut out.

For the purposes of this investigation, and for showing the local variations, a considerable number of detailed pit-sections have been drawn, all to the same scale and with similar colours used for similar descriptions of strata, but in this brief summary it will be sufficient for explaining a few of the principal points on which conjectures are hazarded, if we refer to only one or two of the Somersetshire pits, and to the general typical section of the Gloucestershire Coal-measures by David Williams, pp. 207 to 212, vol. i. Memoirs of the Geological Survey, or Sheet 11 of the Survey's Vertical Sections; it being suggested that this general section contains, with of course local variations, most, if not all, of the strata to be found in the Coal-measures of Somersetshire, and that the equivalents of the Radstock measures are not, as usually supposed, missing in it, but to be found in a totally different position to that in which we have been accustomed to look for them.

If we take the sections of pits which are considered to have been sunk through both the Radstock and the Farrington measures, as at Old Grove or Braysdown, we shall find, that if the measures beneath the red shales, at those places, are correlated, as is usually done, with the Gloucestershire upper series, there is plenty of room and to spare on the Gloucestershire section, for the red shales, and for the whole of the Radstock group above them, but that no such seams occur in Gloucestershire in the position in which, taking the Old Grove or Braysdown intervals, we should expect to find them. If, however, we take the section of the Farmborough sinking as representing the Somersetshire equivalents of the Gloucestershire upper series, including the Gloucestershire measures above the upper series coals, we find a very striking resemblance, apart from the commercial value of the coals, between the Farmborough and Gloucestershire sections; so that it appears as if the commonly supposed absence of the Radstock measures in Gloucestershire can scarcely be explained by saying that the Gloucestershire measures, as now existing, do not extend sufficiently in ascending order to include the Radstock measures, which are usually stated to have once existed in Gloucestershire, but to have been removed by denudation.

Similarly, the position of the red shale bed in Gloucestershire, supposed to be a remnant of the red shales dividing the Radstock from the Farrington measures, is vastly higher above the Gloucestershire upper series seams, than the red shales at Old Grove are above the so-called Farrington seams at that place.

Again referring to the Gloucestershire general section, it will be found that red shales occur in no less than four different positions—

1st. The bed already referred to near the top of the section, about eighteen feet thick only. 2nd. Below the Gloucestershire 'Great' Vein, between it and close to the coal next below it. 3rd. Immediately above, and resting on, the Pennant. 4th. In three beds of similar thickness to those at Old Grove and Braysdown, about one-third of the distance between the Pennant and the Millstone Grit.

It is suggested that these last three beds of red shale may be the Gloucestershire equivalents of the red shales in Somersetshire, which are taken as dividing the Radstock and Farrington groups at Old Grove and Braysdown, and that the real Farrington group, that is to say, the group worked at Farrington Gurney and Old Mills, are, not the veins proved at Old Grove and Braysdown below the red shales there, but a group lower still in the lower series, reaching downwards nearly to the Millstone Grit, instead of to the top of the Pennant as usually supposed.

At Farrington Gurney Colliery, immediately below the New Red Sandstone, a bed of red-coloured shale was passed through, in all probability merely ordinary grey shale coloured red by infiltration from the red ground next above it, as no such red shales occur at, or near to, a similar distance above the 'Cathead' Vein at Old Mills, and the position of this bed of red shale at Farrington Gurney is quite at variance with the position in which, from Old Grove or Braysdown data, the Somersetshire red shales should occur.

Cases are known in which this red colouration extends to a considerable depth beneath overlying red ground, the colour being not merely in the joints and bedding planes, but permeating the entire substance of the shales.

If the detailed sections at Old Mills and at Ludlows, Radstock (above the lap), are placed side by side, with the veins called at both places 'Middle' Vein, together, a very remarkable resemblance, in the details of two sections of which the component parts are arranged in a peculiarly distinctive manner, may be observed: so much so that the section at one place might almost be taken as the section at the other. This resemblance is sufficiently remarkable to afford grounds for suggesting, that the strata at these two places may really be identical.

This would lead to a further suggestion that the veins at Ludlows above the lap, as well as the Farrington veins, may possibly be of the lower series, and that the detached masses of Carboniferous Limestone at Luckington and Vobster may be, comparatively speaking, in their true places as regards the suggested lower series veins at Radstock, as far as measures above the slide are concerned. In short, that the amount of the slide may be far greater than usually considered, and that these masses of limestone, and the lower series above them, may either have been brought down by a simple slide or landslip, from their original position on the Mendips, or that there is an anticlinal between Norton Hill and New Rock. The former hypothesis would involve a distance moved, of, roughly, a mile or more, but instances have occurred, even in the last century, of masses of ground having travelled nearly four miles during landslips.—Lyell's Principles, vol. ii. p. 130.

It is not suggested that all the Radstock measures are, as suggested for those at Ludlows above the slide, equivalent to the Farrington Gurney or Old Mills measures, but that the remainder are in reality, as usually supposed and proved, above the red shales, but beneath the Pennant, and so of the upper portion of the lower series.

It has been remarked that the position of the Pennant gives the key to the understanding of the whole district, and so it undoubtedly would if we could be certain that it really was the true Pennant we had selected as our starting-point; but as it has already been shown in the Kingswood district, that a Coal-measure sandstone, long considered to be Millstone Grit, was in reality not so, we are by no means certain that sandstones, long considered to be true Pennant, are so in reality, merely on account of the length of time during which they have been so called.

There are several heavy beds of sandstone which have been sources of confusion as to the true Pennant (confining the term Pennant to that of the Geological Survey, and including its extension downwards in the Nettlebridge and other districts); amongst them is a bed 66 feet thick as sunk through at Old Mills, the base of it being 63 feet above the "Cathead" Vein there, which bed of sandstone is suggested as lying between the bottom of the sinkings at Old Grove, Braysdown and Grayfield and the top of the suggested true Farrington measures; possibly giving rise to the belief that Old Grove, etc., were supra-Pennant. This bed of sandstone is also very prominent at Temple Cloud, being somewhat thicker and several times repeated by faults there, and has often been described as true Pennant at that place, apparently principally on the grounds that it has been quarried for building purposes, as its thickness is easily to be measured.

The other sandstone beds which have done duty for Pennant need not be discussed in this summary; it is sufficient to remark that, apart from the evidence afforded by organic remains, it is often impossible, from lithological character alone, to be certain whether a specimen is Millstone Grit, Pennant, or one of the other Coal-measure sandstones. Frequently the lithological character is so entirely distinct, that any one could tell the difference, say, between a specimen of Millstone Grit and Pennant; but this marked difference sometimes merges into a marked resemblance, and it may often be impossible to obtain organic remains to decide the question. It is always to be remembered that sandstones, even if of no very great thickness, are apt to claim an undue share of attention as to the proportion of a district that they occupy, partly owing to their hardness and the consequent difficulty or expense in working in them underground, and partly from their prominence (from hardness) at the surface, rendering the observer apt to neglect the greater bulk of softer measures which do not show themselves in such an obtrusive manner.

Other subjects in connexion with the correlation of the district are treated of in the original of this summary, the lucidity of which, it is feared, suffers somewhat by compression and by the absence of the drawings showing suggested correlation of seams; amongst them—

As to the process by which the commonly accepted theory has arisen from the extremely complicated structure of a district in which it is perfectly impossible to trace on the maps boundaries of series or crops of strata by flowing curved dotted lines, as sometimes attempted.

That some different conclusions would have been arrived at if sections had always been drawn to a natural, and not to a distorted, scale, which, however convenient for some purposes, is peculiarly inapplicable to sections consisting largely of inclined strata.

As to the structure in the two mile interval between New Rock and Norton Down, and at Strap Pit, Downside.

As to structure at Coal Pit Lane, Bishop's Sutton and Temple Cloud.

Remarks on some of the faults, with a simple explanation of the cause of inequality of overlap at the Radstock slide fault.

But sufficient has already been written to show the general direction in which inquiry into a confessedly difficult subject may be carried on, and in conclusion the writer begs to thank the many able men engaged in the district who have kindly afforded information, rendering it possible to arrive at conclusions, which, though not put forward by any means as final, or incapable of much improvement by the evidence of further facts from new workings, would, but for their aid, have been founded on insufficient data.

Probably the amount of coal within reach in this district is just as large, whether, though the Coal-measures may be shallower in it than usually supposed, it contains chiefly only one, the lower, series of measures so thrown up and down as to be within reach at almost any point, or whether it consists of three unbroken basins one within the other; and it is evident that if at a colliery we have a set of seams that are found to be of good quality for various purposes, it makes no difference as to their suitability or value, whether they belong to an upper or a lower series, though a correct notion of correlation, if we can arrive at it, is of the highest importance for new winnings or from a geological point of view.

## III.—Notes on some Peat Deposits at Kildale and West Hartlepool.[1]

By Alan Grant Cameron,

of the Geological Survey of England and Wales, Member Yorkshire Geological Society.

NEAR Kildale, a small village on the North Yorkshire and Cleveland Railway, not far from the source of the river Leven, a railway cutting close to the station shows, in descending order, the following section.

| | | |
|---|---|---|
| (a) Peat | ... ... ... ... | 14 feet. |
| (b) Sandy underclay | ... ... | 2 ,, |
| (c) Pale marly sand | ... ... | 15 ,, |

(a) This deposit is circular in shape, being 14 feet thick in greatest thickness, thinning away in all directions. It is pale brown in colour, tough and leathery in structure, and appears to consist chiefly of decomposed wood, stumps and roots being easily recognized in it. Remains of Deer, *Cervus elaphus* (Red-deer) and *Cervus tarandus* (Reindeer), have been found in the lower part of the peat, the antlers especially being well preserved.[2]

(b) Below the peat a sandy underclay usually occurs, of variable thickness, the average being about 2 feet. A thin band of bog iron-ore is often at the base of this.

(c) This deposit consists essentially of fine white sand, its yellow marly appearance being due to the great abundance of *Lymnea peregra*, mostly in a broken condition. In some parts, however, this shell may be found in a capital state of preservation, accompanied by minute specimens of *Pisidium amnicum? Helix nemoralis*? and *Acicula fusca*, and fine specimens of *Helix aspersa*.

The sand is sometimes cemented together by the lime in these shells, and has, then, somewhat the appearance of a calcareous tufa. At the base of the cutting, water still collects, issuing from the *Middle Glacial Sands*, upon which the whole deposit rests.

In this water *Lymnea peregra* still occurs in hundreds. There seems little doubt that this deposit is not of any great antiquity, although we have not been able to ascertain, positively, whether human beings lived in this district or not before the peat formation, though it seems more than possible, that this tarn or pond had some connexion with the moat round the old castle, which formerly stood close by, but of which not a stone now remains.

A somewhat similar deposit to the above occurs at the Slake, West Hartlepool, where recent excavations revealed the following section in descending order.

| | | | |
|---|---|---|---|
| (a) Soft peat | ... ... ... | 8 feet | 0 inches. |
| (b) Blue underclay | ... ... | 1 ,, | 10 ,, |
| (c) Boulder-clay ... | ... ... | 10 ,, | 0 ,, |

(a) is a soft peat, brown in colour, containing numerous trees,

[1] This paper is published by permission of the Director General of the Geological Survey.

[2] Seamer Carr (once a lake), near Stokesley in Cleveland, when being drained, was found to be a peat bog, from which numerous skulls and antlers of deer, and the skeleton of a large ruminant, are said to have been dug out. A stone celt was also picked up.

stumps, and leaves matted together. These vegetable remains are natives of the country. Of 24 stumps measured, the greatest circumference was 12 feet, the trees being from 18 to 20 feet in length. Horns of ruminants and the fruit of trees have also been found.[1]

(b) Underlying the peat is a thin bed of blue clay in which the trees probably had root.

(c) Chocolate-coloured Boulder-clay, with pebbles and scratched stones, many being of the fundamental Magnesian limestone and contiguous Trias rocks. Boulders of granite, basalt and nodules of gypsum are also found. Near the base of the clay section is a thin sand bed 10 inches. The "boys" left by the workmen to measure the excavations, in another part of the Slake, showed

| | | |
|---|---|---|
| Sea sand ... ... ... ... | 2 feet | 10 inches. |
| Shell bed, cockles, mussels ... | 0 ,, | 4 ,, |
| Sand ... ... ... ... | 1 ,, | 6 ,, |
| Red clay with pebbles. | | |

The Slake appears to have been a hollow eroded out of slightly inclined Boulder-clay, constituting a fresh-water lake, which merged gradually into a bog or morass, over which in time the sea broke, forming a bay which finally silted up. This peat is part of a so-called sub-marine forest which has long been known to exist between Hartlepool and Seaton Carew. After a hurricane has blown off the superficial covering of sand, the peat can be traced in patches along the shore from Hartlepool as far as the Trias rocks at Seaton.

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## IV.—On a Method of Estimating the Extent of Geological Areas.

By Townshend M. Hall, F.G.S.

For many purposes it is often desirable to form some approximate estimate of the area occupied by a particular deposit, and in working out the topography of any county or district (especially for agricultural purposes), it is frequently necessary to ascertain the relative extent covered by the various formations. This information, in every instance which has come under my knowledge, has been obtained by measuring on the map with a rule, and entering the results, according to the scale, as so many square miles of surface. Nothing being more uncommon in nature than a straight line of boundary, every one who has made the attempt must be aware how impossible it is to reduce with any degree of accuracy to a geometric figure such lines as those to be found on most geological maps, and having recently had occasion to make a calculation of this nature, for Devonshire, I wish to describe a very simple method which I adopted with success.

As an ordinary map is supposed to be a counterpart on a certain reduced scale of the boundaries of the district it represents, so a geological map would be presumed to show the exact limits of each

[1] Young and Bird, in their "Geological Survey," mention having found in this peat at Hartlepool, the remains of insects, particularly the elytra of beetles.

formation. Proceeding on this reasoning, it occurred to me that, instead of the very troublesome and uncertain method of bringing the areas into figures and measuring their superficial extent, it might be quite possible to arrive at equally good, if not better results by means of scales and weights—in other words, by cutting out in the paper the areas according to their outline, and then weighing them separately, the products being taken either as parts of the whole, or compared with one another. To insure success, in addition to accurate weights, an absolute uniformity in the quality and weight of the paper is a *sine quâ non*, and the separate sheets on which the Ordnance Maps are printed would not always fulfil this latter requirement. I was consequently led to adopt a safer and less expensive method than that of cutting up the maps themselves. The area of Devonshire being so large, measuring on the scale of one inch to the mile, six feet in height, by five feet eight inches in width, I could not procure any single sheet of paper of these dimensions: however, two or three copies of the "Times" afforded an excellent substitute, and as it is manufactured by rolls of some miles in length, it may be supposed that it would be uniform both in quality and weight. To prove this, I first laid the sheets over the Ordnance Maps, and cut out very carefully the boundaries of the whole county. Then taking the square mileage of Devonshire from the official returns, I measured off with a rule as large a piece of paper as would represent the square root of this known quantity. The weight of the two sheets when put into the scale exactly coincided, viz. 107·5 grammes. Being satisfied thus far, I proceeded to cut out in the paper all the formations according to the boundaries laid down by the Geological Survey. These portions were weighed separately, placing all the strips representing alluvium together, then all the greensand, and so on down to the Carboniferous and Devonian. The results were then calculated as proportional parts; the whole area of the county being taken as 100, and by this means I obtained the following figures:—

| | |
|---|---|
| Metamorphic Rocks (Start Point and Bolt Head) ... | 0·74 |
| Devonian series ... ... ... ... ... ... | 25·71 |
| Carboniferous ... ... ... ... ... ... | 41·93 |
| Granite ... ... ... ... ... ... ... | 9·88 |
| Triassic series ... ... ... ... ... ... | 14·44 |
| Lias ... ... ... ... ... ... ... | 0·37 |
| Cretaceous ... ... ... ... ... ... | 4·47 |
| Miocene ... ... ... ... ... ... ... | 4·46 |
| Alluvium ... ... ... ... ... ... ... | 2·00 |
| | 100·00 |

I should add for the information of those who may wish to try the experiment, that as newspaper is too thick to admit of tracing the boundary lines through it, I laid a large plate of glass on the map, and with a pen traced the lines on its surface. Before the ink had time to dry, the paper was spread on the glass, when the lines were transferred to it, as in a lithograph.

# NOTICES OF MEMOIRS.

## I.—On the Zone of *Ammonites acanthicus* or *Ammonites tenuilobatus*.[1]

In an elaborate memoir descriptive of the fossils and localities of the zone of *Am. acanthicus* in the Swiss and Savoy Alps, M. E. Favre, after a careful comparison of the fossils with those from other Jurassic strata, together with remarks on the nature and age of the fauna of this zone, gives the following *résumé* of his researches.

1. There is no general break in the Upper Jurassic strata in the Alpine or Mediterranean regions.

2. The zone of *Am. acanthicus* of the Alps of Switzerland and of Savoy is the equivalent, in the Eastern Alps, of the zone of *Am. tenuilobatus*, and *Am. isotypus* and of the zone of *A. Beckeri*.

3. It is the equivalent, in the Jura, of the zone with *Am. tenuilobatus*, and of the zone with *Am. Eudoxus* and *Am. pseudomutabilis*.

4. The zone of *Am. tenuilobatus* is the exact equivalent of the Astarte zone (*terrain astartien*), of which it is only a peculiar facies.

5. The stratigraphical position of the zone *Am. acanthicus* and its palæontological affinities unite it closely with the Kimmeridgian.

6. In all the Alpine region, there is a very marked palæontological line between the zone of *Am. acanthicus* and the strata upon which it reposes, which are, either the zone of *Am. transversarius* or of *Am. bimammatus*. The latter has more affinity with the subjacent strata and ought to be classed in the Oxfordian. There is, on the contrary, a close palæontological relation between the zone with *Am. acanthicus* and the Tithonian strata which overlie it.

7. The general classification which would best suit the whole of the Alpine strata would be to fix the upper limit of the Oxfordian at the base of the zone with *Am. acanthicus*, and to give the name of Kimmeridgian (or Alpine Kimmeridgian) to the whole of the beds comprised between the Oxfordian and the strata of Berrias or the base of the Neocomian. This name should be employed here in the sense which M. Waagen gave to it in 1865; and which M. Loriol also attributes to it; except a slightly less extension of the lower part, the last author makes it to include all the strata to the zone of *Am. transversarius*. However, this latter difference is not very important in this region, since the Corallian *facies* inferior to the zone of *Am. acanthicus* is not here developed. The zone with *Am. acanthicus* would be the Lower Kimmeridgian, and the Tithonian beds the Upper Kimmeridgian. The equivalents of the Jurassic and Alpine *facies* are approximately given in the accompanying Table:

[1] E. Favre, La Zone à *Ammon. acanthicus* dans les Alpes de la Suisse et de la Savoie.—P. De Loriol, Monographie paléontologique de la Zone à *Am. tenuilobatus* de Baden.—Mèmoires de la Société Paléontologique Suisse, Basel, 1877, vols. 3, 4.

| | FRIBOURG ALPS. (Favre.) | LÉMENC. (Pillet.) | EASTERN ALPS. (Neumayr.) | CRUSSOL. (Fontannes, Hug Uenin) | AIN. (Falsan, Choffat.) | ARGOVIA. (Moesch.) |
|---|---|---|---|---|---|---|
| KIMMERIDGIAN. | Upper and Lower Tithonian strata. *Ter. Janitor.* | Beds of the Droquet Vineyard. *Ter. Janitor.* | Upper Tithonian. Sramberg. *Ter. Janitor.* | | Purbeck. Portlandian with *Nerineæa.* | Hattingen Oolite Corallian of Nattheim. |
| | | Couches du Calvaire. *Am. steraspis. Ter. diphya.* | L. Tithonian, Inwald and Rogoznik. *Am. lithographicus, Ter. diphya* and *Cidaris carinifera.* | Calcaire du Château. *Am. steraspis, Am. lithographicus.* | Fish Beds. *Cid. carinifera.* Beds with *O. virgula.* | Plattenkalke (Solenhofen) *A. steraspis, lithographicus.* |
| | Zone with *Am. acanthicus* (*Am. isotypus, ptychoicus, tenuilobatus, Frotho, longispinus, Ter. Janitor.*) | | Zone of *Am. acanthicus* and *Beckeri, Ter. Janitor.* | Zone of *Am. tenuilobatus.* | Corallian (Valfin.) | Wettingen beds. Ptérocérien (*Am. Eudoxus*) |
| | | | Zone of *Am. acanthicus, tenuilobatus, isotypus.* | | Zone of *Am. tenuilobatus,* and *astarte.* | Baden and Astarte beds. (Letzi beds.) |
| OXFORDIAN. | Limestones. *Belem. hastatus, Am. Manfredi, Arolicus, Eralo, bimammatus, Œgir; Collyrites Inburgensis.* | | Oxfordian. | Zone with *Am. bimammatus.* | Corallian. | Wangen beds (Corallian.) |
| | | | | | Beds with *Hemicidaris crenularis.* | Zone of *Am. bimammatus* (Ter. à chailles). |
| | | | | | *Pholadomya.* | Geissberg beds. |
| | | | | Zone of *Ter. impressa.* | Hydraulic limestone with *Ter. impressa.* | Effingen beds (Zone of *Ter. impressa*). |
| | | | | Zone of *Am. transversarius.* | Zone of *Am. tranversarius.* | Birminsdorf beds (Zone of *Am. transversarius*). |

J. M.

## II.—Land Plants in the Silurian Rocks.

Count Saporta, in his report to the Academy of Sciences on the Fern (*Eopteris Andegaversis*), obtained from the Silurian slates of Angers, remarks that this important discovery was forestalled in America, where remains of Silurian land plants had been found. The first of these, found some years ago by Dr. S. S. Scoville, in shale of the Cincinnati group, and provisionally referred to *Sigillaria*, were briefly described in the American Journal of Science for 1874 (p. 31). Dr. Newberry also noticed them in the same Journal (p. 110), and considered they were casts of some large *Fucoids* or marine plants. These remains have been again studied by Prof. Leo Lesquereux, together with other specimens sent to him from the Silurian of Cincinnati and also from the Lower Helderberg sandstone of Michigan, which, from their characters, seem to him to be evidently representatives of land vegetation, and the description of them was communicated to the American Philosophical Society (Oct. 19th, 1877).[1] The following are the species noticed; *Psilophytum gracillinum, P. cornutum, Annularia Romingeri, Sphenophyllum primævum, Protostigma sigillaroides.*

Prof. Lesquereux remarks that the character of these Silurian plants, described by him, give us a microcosmical representation of the flora of the Carboniferous, so simple and at the same time so admirable in the multiple division of its specific forms; and thus we now have represented in the Silurian—

1st. The *Lycopodiaceæ*, by species of *Psilophyton*, diminutive forms but primitive types of the *Lepidodendron.*

2nd. The Ferns, by a species related to *Paleopteris* or to the group of the *Neuropteridæ*, which is the most common species of the coal.

3rd. The *Calamiteæ*, by *Sphenophyllum* and *Annularia*, these forming two sections related to the *Equisetaceæ.*

4th. The *Sigillariæ*, placed by some authors as an order of plants between the Conifers and the Cycadeæ, and here represented by the *Protostigma.*

5th. The Fucoids, represented by *Calamophycus septus.*

J. M.

# REVIEWS.

## I.—The Epoch of the Mammoth and the Apparition of Man upon the Earth. By James C. Southall, A.M., LL.D., Author of the "Recent Origin of Man." Crown 8vo. pp. 430. (London: Trübner & Co., 1878.)

We give the size of this book lest it should be confounded with the royal 8vo. issued by the same writer on the same topic so ently as 1875. This rapid re-composition reminds us of the method of the late Sir Charles Lyell; but although Dr. Southall writes easily, he does not yet possess either the caution in collecting and weighing evidence, or the charming philosophic style which

[1] Proc. Amer. Phil. Soc. 1877, vol. xvii. p. 163, pl. iv.

distinguished our great literary geologist. The new book is however a great improvement on the old. Many lengthy disquisitions are wisely left stored up in the latter, whilst many new facts are referred to, so that the present compact volume is not only cogent in advocacy, but contains much information on the subject on which it treats. When we have observed that there is a lack of original research (to which it does not, however, pretend), we have mentioned the weak point in the work as a contribution to deductive science. The tendency of the work is strongly in favour of a geological chronology substantially in harmony with inferences drawn from the writings of Moses.

Ethnology is referred to, in order to found an argument that the unity of the race requires that the flint-tool men could not have been precursors of the civilized Egyptians. As we do not know that they were contemporaries, they are concluded to have been offshoots and successors; and therefore, as Egyptian civilization is not more than ten thousand years old, so neither can the gravel-drift men be.

The lake-dwellings are removed from the question by proofs of their use within the historical period. "Of course some of them may be 4000 years old; but there is no evidence to prove that the oldest is older than 3000 years." The same is the case with the refuse-mounds, in both hemispheres. The "three ages" are, in Dr. Southall's hands, contracted in dimensions by the proofs that stone and bronze, stone and iron, and all three, have been in use together. The last in Chaldæan tombs; bronze, iron, and sometimes flint, in Assyria; stone, in Egypt down to the eighteenth dynasty; stone and bronze in the Troad down to the seventh century B.C.; that there has been no stone age in Africa,[1] that iron was unknown to at least one great tribe of Scythians at the beginning of our era; that, in America, stone and bronze are found together; that the metals do not appear in Western and Northern Europe until just before A.D., and stone continued afterwards in use also; and, lastly, that in a considerable part of Europe there never was a bronze period at all. He concludes, so far as this branch of evidence is concerned, that there was no gap between the Palæolithic and Neolithic ages, therefore no immensely long period is required. "Behind the Pyramids in Egypt, and the cities of Erech and Calneh in Southern Babylonia, there is *nothing*, and nothing to indicate the earlier presence of the human race. There was no Palæozoic age, in fact, no *stone age*, in those countries." In brief, the argument is,—the first populations of Europe came from Asia; the first people in Asia, those of Chaldæa and Mesopotamia, like the people of Egypt, appear on the scene in a civilized condition from 6000 to 10,000 years ago: the first Europeans can be no older than this. The author quotes the opinions offered at the Stockholm Conference that the first iron age shown in Scandinavia is in the fourth century; and therefore where, as in Scandinavia, this was preceded by a stone age, the latter need not be assigned to any

[1] This seems to be a singular oversight, as stone implements are abundant in Cape Colony and elsewhere, and have been fully noticed.—Edit. Geol. Mag.

great antiquity. Say, with Worsaae, about 3000 years as the age of the Trojan war, at the utmost 2000 years B.C., which is about the date of the closing effects of the Glacial Period. In order to dispose of the primâ facie evidence for great antiquity yielded by the bone-caves, with their undoubted association of man and mammoth, under several successive floors of stalagmite, Dr. Southall undertakes to show from the researches of the zoologists, that the mammoth lived in the South of France, with the reindeer, in comparatively recent times, and therefore he concludes that this was so in England, and that the rate of deposit of stalagmite, and the rapid change of levels, and alteration in physical geography, all occurred within a few thousand years. The evidence as to this is pretty fully referred to, and though the author breaks a lance with Prof. Boyd Dawkins, he nevertheless accepts many of the facts and frequently the opinions of such experts.

The argument of the present work is that the caves of Neolithic age contain bones of the reindeer and cave-bear; these were, especially in Southern Europe, the contemporaries of the mammoth and rhinoceros; the latter cannot therefore be far removed from the Neolithic date. The assumed recent imbedding of the great mammal carcases in Siberia and Ohio is adduced as rendering it "not only probable, but almost certain, that the mammoth, the mastodon, the megatherium, and the tichorhine rhinoceros, were living at a recent date."

"We have thus fulfilled our promise, and proved the recent existence of the so-called Palæolithic fauna. The cave-horse, the cave-bear, the cave-lion, the cave-hyæna, are still living; the cave-lion is mentioned historically in Europe a few centuries before our era; wild horses scoured the plains of Russia a few centuries ago; the urus survived to the sixteenth century; the aurochs still survives; the reindeer is traced down to the beginning of our era, and even to the twelfth century; the great elk survived equally as late; the mastodon and the mammoth, and the woolly rhinoceros, are found under circumstances that imply their existence a few thousand years ago."

Proceeding from this to the consideration of the drift-implements (the real difficulty in the whole case), Dr. Southall argues that the peat of the Somme rests immediately on the implement gravels, and that in the caves, especially those of Belgium, the Neolithic also rests immediately on the Palæolithic, so that there is proof of suddenness and absence of interval between the two, in fact, no gap. He offers the following explanation of the gravels:—

"But how then shall we explain the occurrence of the implement-bearing gravels, eighty feet or more above the present level of the river? Our opinion is, that when those gravels were deposited, the valley was filled by water from bluff to bluff—a body of water one or two miles at least in breadth, and 100 or 150 feet deep. It was the *Palæolithic Flood*, an event now well recognized by geologists. It is a secondary question whether this flood was occasioned by an inflow of the sea, or by the Pluvial Period of Mr. Tylor. That there was such a flood, covering no inconsiderable area in Belgium, in

France, in England, in the valley of the Tiber, in the valley of the Mississippi, and elsewhere, there is no doubt—what Dr. Andrews designates as *the Flood of the Loess.*"

The sponsors for this flood are Messrs. D'Orbigny, Alfred Tylor, Prof. Andrews, and Prof. Prestwich. Perhaps, in analogy to another kind of sponsorship, these gentlemen hardly know what it is that they undertake! If we enlarge our view and take in the intervening plains on which implements have been found in scattered gravels and caves on hill-sides once at the water-level, we have phenomena which cannot be accounted for by any single flood, or by any flood alone, but require several floods, with intervening periods of repose, the whole constituting a great mammalian epoch, during some part of which man occupied and dwelt; after this there was more flood, accompanied with considerable elevation and movement of the surface. The problem is, how long did this post man-and-mammoth period last? Could it all have taken place within a limited period, after the first appearance, and disappearance, and before the re-appearance of man? Can the geological phenomena between the disappearance and reappearance of man be fairly explained on the supposition of their occurrence within the lapse of, say, a thousand years? To these questions Dr. Southall's book brings no direct reply.

The gravels are still mysterious. The time and the force required to rake off a surface of chalk, to roll its flints into pebbles, to grind pebbles into sand, to wash another part of the contents into coloured clays and fine sands, to expose beds of these to the winds so as to create dunes, to have alternate land and water, alternate still and violent waters, occasional inroads of the sea in places now far beyond its reach, to have successive rises and depressions of land, to have big mammals living, dying, and entombed, to have surfaces of vegetation growing and again buried under aerial or watery accumulations, to have man sufficiently settled to cultivate at least some imitative arts, then a displacement and a deluge, and then the slower reduction of rivers to present channels,—these are a few of the difficulties which beset the traveller in his journey amidst Palæolithic deposits. The gravels themselves furnish us with such an inconstant series, that many able men who have given years of study to them are not yet agreed on their chronology. Geological knowledge respecting their duration cannot at present be said to be conclusive either way; and in regard to geological time the "might have been" is not yet superseded by the authoritative "must." The advocates for both sides are still entitled to hold and express their opinions, and if the tendency of recent discovery and discussion has, as a fact, been towards the adoption of the proposition put forward during the infancy of the inquiry, that the mammalian epoch reached far nearer down to our own day than was supposed; yet who shall estimate the duration of that period *antecedent* to human chronicles or even traditions?—to attempt to measure it by our feeble data, is like taking soundings in the ocean with a "two-foot rule"!

A singular illustration is afforded, in the Somme Valley itself, of the comparatively recent occurrence of phenomena similar in appearance to those of prehistoric times. M. de Mercey has described a deposit superimposed on the (Celtic) peat, comprising, first, brick-earth with fragments of Roman pottery and land-shells, having at its base a few pebbles and marine shells, and, lying over it, a bed of river-gravel. If authentic, the events and changes thus indicated must have all occurred since the days of Julius Cæsar. On the other hand we have Mr. Belt, in the current Quarterly Journal of Science, treating the valley-gravels as pre-glacial.

Dr. Southall relies on the conclusions of Professor Andrews respecting the positive age of the remarkable terraces in the river valleys of North America, and on Professor Whichell's calculation on the Falls of St. Anthony, recently brought before the Geological Society of London. The author's conclusion seems to be that the present surface phenomena are principally of glacial and sub-glacial age, in the Northern hemisphere, and cannot be carried back further than about 7000 years, and that land-ice, with all its incidents, lingered in Northern Europe long after the cessation of the Glacial Period proper.

Dr. Southall's volume is not without the liveliness which the advocacy of a particular hypothesis gives; indeed the spirit of the Advocate is oft-times far too prominent; evidence being admitted and conclusions based thereon, without sufficient regard for the reliability of the witnesses cited. It hardly accords with the caution expressed in the preface :—"It is a question which should be decided apart from all theological prepossessions, and in no way prejudiced by any supposed interpretations of a biblical revelation on the subject. It is purely as a question of science that I propose to discuss it ; and if we arrive at a conclusion out of harmony with religion let it be squarely recognized, and let the adjustment constitute a separate task." P.

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II.—The Fenland—Past and Present. By Samuel H. Miller, F.R.A.S., etc., and Sydney B. J. Skertchly, F.G.S. Royal 8vo. pp. 649, with a map, and 27 plates. (1878: Wisbech, Leach & Son; London, Longmans, & Co.)

In the Geological Magazine for May last, we called attention to a Geological Survey Memoir on "The Geology of the Fenland," by Mr. Skertchly. We have now much pleasure in announcing the publication of the handsome and beautifully illustrated work whose title is given above. This work, which contains nearly twice the amount of material, printed on superior paper, and in far better type, than the Survey Memoir, with excellent illustrations, is issued to subscribers at less than half the cost of the Government publication, and even its published price of 31*s*. 6*d*. contrasts very favourably with the enormous (almost prohibitive) charges now put upon the Survey works by H. M. Stationery Office.

This new work on the Fenland is an exhaustive treatise on the Archæology and Natural History of the district. In the Geological chapters Mr. Skertchly supplements the detailed accounts which he gave in his official work, with an amplification of the general results, which are written so as to interest the ordinary reader as well as to furnish food for the geologist. We must content ourselves with briefly indicating some of the many subjects treated here, which are of special interest to our readers, such are the history of the present indigenous fauna, and of that of pre-historic times, the migration and diffusion of species, the causes of changes of Climate. The growth of Peat, the question of Water-Supply, and the subject of Climate and Disease will suggest many topics of interest. Among the subjects more likely to raise discussion are those connected with the formation of the Chalky Boulder-clay, the alternation of Glacial and Interglacial beds, the Palæolithic gravels, and the age of the Brandon Beds. The entire subject is however rich with interest, and the authors have evidently spared no pains and no expense to render their work as complete in every respect as possible.

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III.—Céphalopodes. Etudes Générales; extraits du Système Silurien du Centre de la Bohême. Par Joachim Barrande. 8vo. pp. 253, 4 plates. (Prague and Paris, 1877.)

BARRANDE has completed his magnificent work on Palæozoic Cephalopods. Commenced in 1865 with the publication of the first series of his plates, and continued at irregular intervals but without interruption up to nearly the close of last year, this splendid contribution to science extends to 544 large 4to. beautifully executed plates, and to about 3600 pages 4to. of letterpress.

In the smaller publication we now refer to more especially, Barrande has given us short extracts from the concluding chapters of his work, or those including his "General Considerations of the Cephalopods," and has produced, as it were, a brief summary of the ably reasoned arguments given more in detail in the larger work, so that an excellent general idea may be quickly obtained of the more important conclusions at which he has arrived. From the character of the publication, it will be obvious that it would be impossible to condense into a few lines, for which alone we can find space here, what is already a highly condensed summary of detailed and close reasonings. In his chapter xvii. the reader will find a most interesting *résumé* of all previous researches on the initial form of the *Nautilidæ*, the *Goniatidæ* and the *Ammonitidæ*, in which the position, form, size, origin and object of the cicatrix on the initial cowl of the shells, are fully considered, and the remarkable contrasts offered in these respects in the different groups. He then winds up this chapter with some considerations on the chronology of the groups, and finally a brief statement of all his conclusions on the initial forms of the Cephalopods. As to the vertical and horizontal distribution of the Cephalopoda in Silurian countries, it seems established, that this order has appeared suddenly, and for the first time, at the commencement of the second fauna. At that time the only Cephalopods belonged solely to types of the one family of the *Nautilidæ,* very varied in form, from *Orthoceras* to *Nautilus* and *Trochoceras,* as proved by the second faunæ of the N. American and N. European areas. In Bohemia, the second fauna only offers straight forms of the family, and the "colonies" even have only given two curved forms of the genus *Cyrtoceras.*

The great development of the *Nautilidæ* in Bohemia occurs in Barrande's étage E, in which more than 637 specific forms of the family occur (or including the supplementary lists of Barrande's *Série tardive,* no less than 856 species). No species occur in the beds above belonging to the zones *f* 1, *f* 2, *g* 1, *g* 2, but after this long interval *Nautilus* reappears in zone *g* 3, with three new species different from those of zone E. Meanwhile the genus *Goniatites* is absolutely unknown in the second fauna of all Silurian countries in either continent which have been examined up to date.[1] The earliest appearance of *Goniatites* in Bohemia was during the deposition of Barrande's zone *f* 2, in which he shows the existence of seven species of that type.

Now it is interesting to notice that this epoch of the first appearance of *Goniatites* corresponds to the cessation, which has been just noticed, in the existence of *Nautilus* in Bohemia. But, Barrande remarks, this fact does not tend to prove the filiation of the new type to the more ancient, because, in reality, where the new form, the first *Goniatites,* appeared suddenly in the Bohemian basin, there was not a single *Nautilus* to give birth to them. Further, at its first appearance in zone *f* 2, the genus *Goniatites* furnishes 7 distinct species, while the genus *Nautilus* only furnished 5 during its temporary existence in Bohemia in zone *e* 2 : numbers which are far from corresponding with the slow and successive steps in transformation, admitted by theory. In fact, all the appearances and disappearances have taken place suddenly.

Some time after its first appearance, *Goniatites* seems to disappear during the deposition of the very thick zone *g* 1, at the top of which we again find it. It then continues with variations in the number of its specific representatives through the zones *g* 2, *g* 3, *h* 1, attaining its maximum number (14) in *g* 3. Now it is precisely during the deposition of this same zone that we find *Nautilus* reappearing with three species. It is difficult to imagine how it reproduces itself after so long a cessation, precisely at the time of the maximum importance of the *Goniatites,* which theory would indicate as replacing the *Nautili.*

Barrande here gives an amusing (p. 75) imaginary discourse of an evolutionist lecturer on the derivation of the *Goniatite* from the *Nautilus,* "which it replaces at its disappearance from the seas of Bohemia without our exactly knowing why," "mais sans doute par l'effet de la selection naturelle"—and discusses the total discordance which is here proven between theory and fact, with reference

[1] The question of the asserted occurrence of two forms of *Bactrites,* one in Bohemia, one in Russia, in the second fauna, will be found fully discussed in vol. iii. of Texte, p. 804.

to the initial portion of the shell of the Cephalopods in the three families of the *Nautilidæ, Goniatidæ,* and *Ammonitidæ.* And closes this portion of his paper by proposing a few questions, which, in his opinion, must be answered before we can establish any idea of filiation, or derivation, between the *Nautilidæ, Goniatidæ,* and *Ammonitidæ.* These are—if true that the *Goniatites* and *Ammonites* are derived from the *Nautili,* why is their siphon invariably on the convex side ? why is it never inflated, or nummuloid as in the *Nautilidæ?* why, under these two points of view, is there never any trace of atavism, amongst the *Goniatidæ* and *Ammonitidæ*?

The second part of the work under review is devoted to the discussion of the vertical distribution of the Cephalopods in Palæozoic countries. It will be found to give a wonderfully detailed and careful summary of all the known facts, as to the occurrence in successive formations of the various genera and species. The horizontal distribution, or occurrence in local groups, is also fully discussed. And the special distribution in Bohemia given in much detail—into which we cannot follow the author. In this portion of his work, also, no possible opportunity is omitted to indicate the apparent contradiction between facts and any theory of evolution.

The third part gives a general *résumé* of the author's studies on the Cephalopods, taken under the separate heads: 1. Investigation of any traces of evolution of the Cephalopods, in the first appearance and successive re-appearance of generic types, and in specific forms. 2. Similar investigation as to each of the elements of the shell in the Palæozoic Cephalopods. 3. Remarkable peculiarities—(*a*) in structure of shell; (*b*) unexplained connexion, between different elements of the shell; (*e*) forerunners of types—avant-coureurs—the species 'prophétiques' of Agassiz; (*f*) connexion between the existence of large siphons and the brief duration of certain types, and the geographical distribution of their species; (*g*) the anachronism exhibited by the forms intermediate between generic types. And then, 4. Final conclusions.

With some additional notes, among which will be found quoted, with much satisfaction, the labours and conclusions of Mr. T. Davidson on the Brachiopoda; of M. Grand'Eury and Mr. W. Carruthers on evolution in the Vegetable Kingdom, as represented by fossil plants, M. Barrande concludes this very important and remarkable brochure. We shall just give in a few words his final conclusions. It will be obvious from the headings we have given, that it would be impracticable to give the necessary space for any full discussion of his results.

He says (p. 230): On the whole, we have *not* discovered any trace of the supposed evolution, either in the first appearance or in the vertical reappearance of the generic types of the Cephalopods; or in the appearance and succession of their specific forms; or in the appearance of the elements of the shell. On the contrary, we see at all ages, the genera, the groups and the species, without any genetic connexion, rise and disappear with a suddenness and without intermediate forms, which are inexplicable; while we have also proved a remarkable stability in the generic characters, in the specific distinctions and in the elements which form the shell of molluscs of this order. "The theory of evolution of the Cephalapods, like that of the Trilobites, appears to us to be a mere product of the imagination without any foundation in fact."

We have given M. Barrande's conclusions with all their force, though necessarily without the detail of argument which he has brought to their support. We cannot follow him in this detail, but we must suggest great caution in admitting as 'proven' all that is assumed as such in this brochure. For instance, in his general conclusions, he starts by recalling two predominant facts, so predominant in truth as to rule everything else. Now the first of these is the absence of Cephalopods in the primordial Silurian fauna. It may be, and we admit that M. Barrande has fully and fairly quoted the evidence, that no Cephalopod has as yet been recognized in this fauna. But he would be indeed a bold man who, therefore, would assert that no Cephalopod existed. Is there not in this, as in so much so-called Geological reasoning, a little suspicion of what a logician would call "arguing in a circle"? Has the "primordial" age of the several groups been determined on evidence altogether independent of such considerations of fossil data? Has not the belief in this supposed absence of Cephalopods from the earlier stages been sufficient to determine at once, that any beds in which they were found could not be of that epoch? Has there always been sufficient care, and sufficient detail given to analysis of the accompanying facts? In any case, the attempt to base such important and widely influential conclusions on what is confessedly purely negative evidence (if there can be such), is fraught with danger, and is to be most jealously guarded. And a reference to M. Barrande's details shows in how very many particulars he has no other evidence to rely upon.

We rejoice to think that he has been enabled to complete this magnificent contribution to Palæontology, and we trust sincerely he may yet be spared to carry out the intentions which he announces as now in progress—the rapid issue of more than 120 plates of the Palæozoic Gasteropoda, and of 114 plates of Brachiopoda (all ready printed), besides a very large series of the Acephala. In common with every palæontologist, we look with anxious longing for these valuable contributions to the literature of our science; and whether the progress of his investigation may lead to the confirmation of his present views as to the illusionary nature of any theories of evolution, or may tend to modify these, we know that we shall have from M. Barrande what is beyond all theory in value,—the carefully worked out, and carefully thought out expression of his honest opinions. We most heartily congratulate him on the completion of the Cephalopods, and wish him every success in the further prosecution of his labours.

T. Oldham.

IV.—Geological and Geographical Atlas of Colorado, and Portion of Adjacent Territories. By F. V. Hayden, U.S. Geologist-in-Charge. Published by the Department of the Interior, under the United States Geological and Geographical Survey of the Territories, 1877.

We have just received, through the agency of the Smithsonian Institution, this grand contribution to the Geology of America. Most of our readers are aware that a general survey of the very large and important, though often very inaccessible areas, known as "The Territories," was organized in the year 1867, and those who are observers of American progress have watched with increasing interest the vast advances which have been made in this Survey under Dr. F. V. Hayden. Very few weeks have elapsed since we received Vol. VII. of the Memoirs of the Survey, being a large quarto vol. of 370 pages and 65 plates, on the Tertiary Plants of the West, of which another similar volume (VI.) formed the Cretaceous Flora.—1877 saw the appearance of a very large volume on North American Rodentia (for the researches of this all-embracing Survey are directed to many subjects besides Geology), while a year or two before we had a volume on the Cretaceous Vertebrata by Cope, illustrated with 57 beautifully executed plates. The Bulletin (of shorter papers) has already reached the middle of Vol. IV.—In 1873, the work of the Survey was systematically commenced in Colorado. And here we have the results of four years' labour (1873–74–75–76) produced and published in a finished state in the year 1877!

And such four years of labour as these must have been! an area *exceeding that of Ireland*, in parts most inaccessible, everywhere difficult to travel in, open to disturbances, or fears of disturbance, from unsettled Indian tribes, where everything had to be carried with the observer, and he thrown entirely on his own resources, and such limited aid as he could bring with him; such an area has been triangulated, measured, physically examined, and mapped; its drainage carefully determined, its economic and agricultural divisions noted, and its geological structure carefully investigated.

We have no hesitation in saying that Prof. Hayden may justly point to this as a success, rarely ever approached, probably never equalled. And may justly recount with pride the names of those few who have so ably and so untiringly carried out his wishes.

The Atlas consists of twenty sheets of large double elephant size. These are in two series: first, of 4 sheets, which are general, and embrace the entire area on a scale of 12 miles to one inch. These show (1) The Triangulations, (2) The Drainage, (3) Economic Map, (4) General Geological Map. The second series consists of 12 sheets, in pairs, six representing (plain) only the topographical features of different parts: N.W., N., Central, W., S.W., and S. Central Colorado. And six sheets exactly corresponding, on which the geological lines and colours are given; then there are two sheets of geological sections, and two of panoramic views. The detailed maps are all on the scale of four miles to the inch, and embrace each $2\frac{1}{2}$ degrees of longitude, and $1\frac{1}{4}$ degree of latitude—thus covering the entire area of Colorado, and some adjacent parts of Utah, Arizona, and New Mexico. These maps are also contoured, the contour lines representing, approximately, intervals of 200 feet vertical.

All these maps are very beautifully drawn and beautifully printed, and are types of careful, clear, and excellent work. The colouring is also admirably printed, with a wonderful transparency and evenness, and with really admirable "register." Altogether the execution of the sheets of this noble atlas leave nothing to be desired.

We cannot pass on without noticing the two sheets of panoramic views. We have had in this MAGAZINE opportunity before now of drawing attention to the really effective aid which such views give to the student in a ready and clear understanding of the descriptions of a country.[1] And we think the simplest inspection of the few given in this atlas will be quite sufficient to prove to any one the immense value of such outlines in enabling those who have not seen the districts, to realize the facts. Who can compare the curiously broken and rugged outline of the quartzite group of the San Juan Mountains as seen from the Rio Grande Pyramid (Sheet xx.) with the peculiar serrated and jagged peaks of the trachytic mass of the La Plata Mountains, looking east from Mount Hesperus, on the same sheet, without carrying away with him a vivid conception of the two areas, and without, at the same time, we may remark, being struck with the vast difficulties the surveyors have had to contend with in such work? True: the ground is well visible, there is no dense jungle and no thick undergrowth of impassable and deadly vegetation to interfere with his progress. But the very loneliness—the conviction of desolation, would in itself numb the energies of many; and double honour is due to those whose unflagging interest in their researches, and whose untiring devotion to their work, have enabled them to complete this great task.

It is too late now to devote any space to a more detailed examination of the geological information given on these maps. We shall probably have other opportunities of returning to the subject. But we could not avoid at once congratulating Prof. Hayden on the completion of this grand atlas, and on the success which has thus crowned the labours of his very efficient and zealous staff. If any sense of shame yet remain in some other Survey staffs, we cannot help hoping that they may be excited, by the comparison, to a little more earnest and single-minded devotion to their labours than has of late years distinguished them.

There is still an immense area before Prof. Hayden. And we shall look with eagerness for successive atlases of the other "Territories" also.

It would be injustice to our American brethren to omit noticing, with the highest approbation, the marked liberality with which the costly and valuable labours of these State Surveys are distributed to all who are likely to take a real interest in the subject, or can in any way reciprocate by exchange of similar publications. There is not a library of any value for the student of Natural Science in this country

[1] See GEOL. MAG. Decade II. Vol. V. April, 1878, p. 174, etc.

which is not enriched by a series of these American Survey Publications—while he might search through half the counties in the kingdom before he could obtain access to a copy of the publications of the Geological Survey of Great Britain. In early years, a wise and well-judged arrangement was made by which such publications were issued at an uniform rate, which was reasonable, and which brought them within reach of most persons interested. But lately a new system, so far as we can learn without any public sanction, has been introduced, and all expenses whatever incurred in the printing, etc., of a Report are put to the charge of that Report, and as only small editions are printed, they naturally enhance the cost of each pamphlet or volume. But in addition to this, not only is this charged at a fixed rate per sheet or page, but the cost of every alteration is added, and the public is made to pay for the incompetence or carelessness of the editor, who, not knowing exactly what it is he wants, has the same passages printed over again two or three times. Thus it happens, that reports are saleable only at a price which perfectly forbids their purchase. While the works are produced on paper more like what is used for the columns of a halfpenny newspaper, than what would be expected in valuable and costly scientific reports. And the illustrations are either of the poorest and worst executed kind, or are so destroyed by bad printing on bad paper that they are simply disgraceful. We are well aware that this is not caused by the Officers of the Survey itself, and that, in fact, they suffer severely by it and regret the result as much as the public at large, but the facts are as stated.

Nothing of this kind will be found in this Atlas of Colorado, the paper is excellent, the printing is excellent, the execution is excellent.

T. Oldham.

## REPORTS AND PROCEEDINGS.

I.—Geological Society of London.—June 5, 1878.—John Evans, Esq., D.C.L., F.R.S., Vice-President, in the Chair.—The following communications were read:—

1. "On the Quartzites of Shropshire." By Charles Callaway, Esq., M.A., B.Sc., F.G.S.

In a former paper (Q.J.G.S. xxxiii. p. 652) the author indicated that part of the so-called quartzites of the Wrekin are "Hollybush Sandstone"; in the present communication he shows that the whole, both in the Wrekin and Church Stretton areas, are of Cambrian or Precambrian and not of Caradoc age.

In the Wrekin area the quartzites rest unconformably against the volcanic axis in a nearly continuous band, dipping away from it at angles of from 30° to 55°, their present position being due to its elevation. The volcanic rock is a bedded Precambrian tuff, which reappears in Lawrence Hill and the Ercal, also accompanied by quartzites overlain by Hollybush Sandstone. Caer Caradoc belongs to the same volcanic series, and the quartzites reappear on its S.E. flank, overlain by Hollybush Sandstone containing *Kutorgina cin-*

*gulata* and *Serpulites fistula*, above which follow the Shineton Shales, and next, separated by a fault, the Hoar Edge grits (Lower Caradoc). The author believes that the apparently conformable succession here is due to parallel faults. Along the S.E. flank of the Wrekin the quartz rock dips S.E., while the volcanic rocks dip N., and fragments of the latter are contained in its base. The author is inclined to think this a friction-breccia, and the junction a faulted one. He also regards the junction with the Hollybush sandstones as a faulted one, and maintains that in any case the quartzites are older than the latter rocks, which are sometimes considered the equivalents of the Ffestiniog group, and by Mr. Belt to be Menevian. The quartzites can hardly belong to any part of the Upper Cambrian, and the author passes on to consider the various positions which they may be held to occupy, and gives reasons for thinking that they are Precambrian. The only fossil that has been found in them is a supposed worm-burrow. In conclusion the author expresses the opinion that the Stiper-stones quartzites are of Arenig age.

2. "On the Affinities of the Mosasauridæ, Gervais, as exemplified in the Bony Structure of the Fore-fin." By Prof. Owen, C.B., F.R.S., F.G.S., etc.

In this paper the author commenced by discussing the opinions expressed by different anatomists as to the indications of relationship furnished by the structure of the fore-limb, and stated that in 1851 he had referred *Mosasaurus* to a Tribe, Natantia, of the Order Lacertilia. Since then Prof. O. C. Marsh has published a reconstruction of the fore-limb of the Mosasauroid *Lestosaurus simus*, and from a comparison of his figure with the bones of the same parts in Cetacea, Plesiosauria, and Lacertilia, the author showed that the resemblance in structure was closest with the last-named type, of which the fore-foot of *Monitor niloticus* was taken for comparison. In the relative length of the digits and the number and form of the phalanges, the Mosasauroid fore-foot was shown to agree most nearly with the Lacertilian type. With regard to the presence of a zygosphene and zygantrum in vertebræ of *Clidastes*, cited by Prof. Cope in favour of his approximation of the Mosasaurs to the Ophidia and his establishment of the Order Pythonomorpha, the author remarked that the trunk-vertebræ of the Iguanidæ show zygosphene and zygantrum, but with modifications which serve to distinguish the Iguanian from the Ophidian vertebræ, and that until we have the opportunity of comparing the Mosasauroid vertebræ with those of both these types, the mere presence of these parts cannot be accepted as conclusive.

3. "On new Species of *Procolophon* from the Cape Colony, preserved in Dr. Grierson's Museum, Thornhill, Dumfriesshire; with some remarks on the Affinities of the Genus." By H. G. Seeley, Esq., F.L.S., F.G.S., etc., Professor of Geography in King's College, London.

The species described by the author were named by him *Procolophon Griersoni*, *P. spheniceps*, and *P. platyceps;* they are represented by skulls imbedded in a hard red ironstone matrix, apparently concretionary, and were collected at Donybrook, Queenstown district, Cape Colony.

With regard to the systematic position and affinities of *Procolophon* the author remarked that the presence of two distinct nares shown in his specimens removed the genus from the family Mononarialia, of the Order Theriodontia, in which it was placed by its founder, Prof. Owen. He further discussed in considerable detail the characters upon which the Order Theriodontia is founded, and arrived at the conclusion that this group must be regarded as synonymous with the family Cynodontia, which, with the Dicynodontia and Cryptodontia, make up Prof. Owen's Order Anomodontia. The genus *Procolophon*, displaying no distinguishable canines, does not possess the chief character of a Cynodont, and the author preferred to regard it as belonging to a parent type from which the dental modifications of the Anomodontia have been derived, and, from its apparent relationship to *Hatteria*, as forming an extinct family of the Rhynchocephala. Hence the question arises, whether the Anomodontia and the South-African forms described as Dinosaurs might not be united with the Rhynchocephala to form a subclass of Reptilia.

4. "On the Microscopic Structure of the Stromatoporidæ, and on Palæozoic Fossils mineralized with Silicates, in Illustration of Eozoon." By Principal Dawson, LL.D., F.R.S., F.G.S.

The fossils included in the group Stromatoporidæ occur from the Upper Cambrian to the Upper Devonian inclusive, and are especially abundant in the Trenton, the Niagara, and Corniferous formations. The author regards *Stromatopora* as a calcareous, non-spicular body, composed of continuous, concentric, porous laminæ, thickened with supplemental deposit, and connected by vertical pillars, most of which are solid. The surface shows no true oscula; but perforations made by parasitic animals have been mistaken for such. From the structure they could not have been related either to Sponges or to *Hydractiniæ*, and still less to Corals; they are truly Foraminiferal, and may be regarded as the Palæozoic representatives of *Eozoon*. *Stromatopora* occurs infiltrated with calcite or silica, or with its structure wholly or in part replaced by crystalline silica or dolomite. The author concluded his first section with the characters of the genera which have been included in the Stromatoporidæ.

In the second part he noticed a number of facts relating to the occurrence of hydrous silicates, of the nature of serpentine and loganite, infiltrating Palæozoic fossils and illustrating the mode of occurrence and mineralization of *Eozoon*. Instances of this kind were said to be exceedingly common, showing that such silicates, whether originating as direct deposits from water, or as products of the decomposition of other minerals, are efficient agents in the infiltration of the pores and cavities of fossils, and have played this part from the earliest geological periods.

5. "On some Devonian Stromatoporidæ." By A. Champernowne, Esq., F.G.S.

The author's object in this note was to give some account of the origin of a fine series of Stromatoporidæ presented by him to the Society. They were all from the Great Devon Limestone at Dartington, near Totnes, and were obtained from a spot in the Pit Park

Quarry, where the dolomitic rock, instead of being hard and crystalline, is friable and almost sandy. The Stromatoporidæ appear to have grown in the position in which they are found. They can be traced for a few yards from the friable portion of the rock, but gradually become merged in the crystalline rock, and then their internal structure is obliterated. The author noticed the various Corals, Crinoids, and Brachiopods which occur associated with the Stromatoporidæ. The author regarded the Stromatoporidæ as a somewhat heterogeneous mixture of organisms, but did not believe that they were, as had been asserted, originally siliceous. Some seem clearly to be of a structure like that of the Milleporidæ. With regard to *Caunopora placenta* (Lonsd.) the author quoted Prof. Phillips's remarks as to the characters of the tubes traversing its mass. He had observed in sections from near Teignmouth, that the axis of the tube is lamelliferous, giving some appearance of a columella.

6. "On a new Species of *Loftusia* from British Columbia." By George M. Dawson, D.Sc., F.G.S., Assoc. R.S.M., of the Geological Survey of Canada.

The specimens on which the genus *Loftusia* was founded in 1869 were brought from Persia by Mr. Loftus, and the rock from which they were derived was conjecturally assigned to the earliest Tertiaries. The species now described (*L. columbiana*) is found in a limestone probably of Carboniferous age, and occurs in the banks of Marble Cañon, Frazer River. It appears to be very thick, but may be repeated by folds. Crinoidal columns and *Fusulinæ* have been sparingly found in it. Where the *Loftusia* is abundant it becomes almost the sole fossil, and sometimes occurs as numerously as *Globigerinæ* in the Atlantic ooze.

*Loftusia columbiana* differs from *L. persica* in size, its longer diameter averaging about 0·3 inch, and its shorter one 0·19–0·2 inch. No regular furrowing of the outer surface has been observed, but some specimens show a tendency to acervuline growth. The structure is very like that of *L. persica* as described by Mr. Brady, although the nucleus is not quite so distinctly cancellated; the test consists of a primary layer coiled upon itself, with "secondary" septa very oblique to it, and "tertiary" columns expanding at the outer ends into cross-like "rafters," supporting the roof formed by the primary lamina. A loose cancellated growth also depends from the roof between these rafters, analogous to a more regular structure observed in *L. persica.* The usual number of convolutions is about 10, but as many as 17 have been observed.

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II.—June 19, 1878.—John Evans, Esq., D.C.L., F.R.S., Vice-President, in the Chair.

*Important Notice.*—The Chairman stated that a letter had been received from Count Gaston de Saporta, announcing that the Congress of the French Association for the Advancement of Science will be this year held in Paris from the 22nd to the 29th August. As President of the Geological Section, M. de Saporta invites Fellows of the Geological Society to take part in the proceedings of this

Congress, which will be followed by two other *réunions* of exclusively geological interest, at which Fellows of the Society may be present. Announcements of an intention to attend the Congress, or to send memoirs to be laid before it, and applications for further information, may be addressed to the Secretary of the French Association, 76, Rue de Rennes, Paris; or direct to the Comte de Saporta, Aix-en-Provence, Bouches-du-Rhône.

The following communications were read :—

1. "On the Section of Messrs. Meux & Co.'s Artesian Well in the Tottenham Court Road, with Notices of the Well at Crossness, and another at Shoreham, Kent; and on the probable range of the Lower Greensand and Palæozoic Rocks under London." By Prof. Prestwich, M.A., F.R.S., V.P.G.S.

The well-known boring at Kentish Town in 1856 showed the absence at that point of Lower Greensand, the Gault being immediately succeeded by hard red and variegated sandstones and clays, the age of which was at first doubtful, but which were finally considered by the author to approach most nearly to the Old Red Sandstone near Frome, and to the Devonian sandstones and marls near Mons, in Belgium. The existence of some doubt as to this identification rendered the boring lately made at Messrs. Meux's brewery particularly interesting, and the method of working adopted by the Diamond-boring Company, by bringing up sharply cut cores from known depths, gave special certainty to the results obtained. The boring passed through 652½ feet of Chalk, 28 feet of Upper Greensand, and 160 feet of Gault, at the base of which was a seam, 3 or 4 feet thick, of phosphatic nodules and quartzite pebbles. Beneath this was a sandy calcareous stratum of a light ash-colour, passing into a pale or white limestone, and this into a rock of oolitic aspect. Casts and impressions of shells found in this bed showed it to be the Lower Greensand, whose place it occupied. The boring was carried further in the hope of reaching the loose water-bearing sands of this formation, but the rock became very argillaceous, and when 62 feet of it had been passed through, the bore entered into mottled red, purple, and greenish shales, dipping at 35° in an unascertained direction. These beds continued through a depth of 80 feet, when, their nature being clearly ascertained, the boring was stopped. The fossils of these coloured beds, which included *Spirifera disjuncta, Rhynchonella cuboides*, and species of *Edmondia, Chonetes*, and *Orthis*, show them to be of Devonian age. Thus, the existence of Palæozoic rocks at an accessible depth under London, and the absence of the Jurassic series, as maintained long since by Mr. Godwin-Austen, is experimentally demonstrated.

These facts are of interest in connexion with the question of the possible extension of the Coal-measures under the Cretaceous and Tertiary strata of the south-east of England. The beds found at the bottom of Messrs. Meux's boring are of the same character as the Devonian strata which everywhere accompany the Coal-measures in Belgium and the north of France, being brought into juxtaposition with them by great faults and flexures. The author refers especially to a remarkable section at Auchy-au-Bois, in the western extremity of the Valenciennes coal-field, which is particularly interesting from its furnishing evidence that the Hardinghen coal-field, between Calais and Boulogne, is a prolongation of that of Valenciennes, and because the same strike and a prolongation of the same great fault observed at Auchy-au-Bois through Hardinghen would carry the southern boundary of any coal-field in the south-east of England just south of Maidstone, thence passing a little north of London. Hence it is in the district north of London that there is most probability of the discovery of the Carboniferous strata. The extent of country in which shafts could be sunk to the Palæozoic strata will, however, be limited by the presence of the water-bearing Lower Greensand, which probably reaches close to London in the south, reappears in Buckinghamshire and Bedfordshire, 30 or 40 miles north of London, and probably extends some distance towards the city under the Chalk hills of those counties and Hertfordshire.

The nature of the representative of the Lower Greensand in the boring, and the characters of the fossils contained in it, lead the author to the conclusion that in it we have a deposit produced near the shore of the Neocomian sea, here probably consisting of cliffs of Devonian (or Carboniferous) rock. From these cliffs the calcareous material which here replaces the usual loose sands of the Lower Greensand was perhaps derived by the agency of springs; and the shore-line itself must be situated between the south end of Tottenham Court Road and the Kentish Town boring. The sandy beds of the Lower Greensand will probably be found to set in at no great distance to the southward, presenting the conditions necessary for storing and transmitting underground waters. A test boring made by Mr. H. Bingham Mildmay at Shoreham Place, about 5 miles from Sevenoaks, and in which the Lower Greensand was met with at about the estimated depth (450 feet) and furnished a supply of water, seems to confirm these views.

2. "Notes on the Palæontology and some of the Physical Conditions of the Meux's Well Deposits." By Charles Moore, Esq., F.G.S.

The author remarks that the various deep well-borings around London have abundantly proved the correctness of Mr. Godwin-Austen's inference that the Palæozoic axis of the Mendips is continued beneath the Secondary rocks of the south-eastern counties. Mr. Moore has himself shown that where these Palæozoic rocks finally disappear under the Secondary strata, there are found at the unconformable junction of the two formations a set of deposits indicating the existence of very peculiar physical conditions, and containing an admixture of fossils from very different geological horizons. Hence he was led to inquire whether any trace of similar abnormal deposits might be found in the deep well-borings of London.

With this view he set to work at washing some of the materials supplied to him from the Meux's well, and studying the minute and often microscopic organisms thus obtained.

The Chalk was not particularly examined; but from a single small sample of Upper Greensand he obtained numerous Foraminifera and Entomostraca, including one Cyprid new to science.

The Gault yielded 16 genera and over 30 species of Foraminifera, and 20 species of Entomostraca, 4 of which are new, together with many young forms of Gasteropods and Cephalopods.

But the chief interest of Mr. Moore's investigations centres in the 67 feet of strata intervening between the Gault and Devonian. In this marly and oolitic-looking deposit he found no less than 85 different kinds of organisms, exhibiting a singular admixture of marine and lacustrine forms of life. Foraminifera are rare, but Entomostraca and Polyzoa are very abundant. Some genera are found, such as *Carpenteria*, *Saccammina*, *Thecidium*, and *Zellania*, of which the range in time is greatly extended by these investigations.

The author fully confirms Mr. Etheridge's reference of the beds in question to the Neocomian period, widely as they differ in physical characters from the Lower Greensand strata of the south-east of England. From a careful study of the nature and condition of preservation of the minute organisms, he concludes that the deposits which contain them were formed at first in shallow lacustrine hollows on the surface of the Devonian rocks now lying buried at a depth of 1000 feet below London, and that these lakes were invaded by the waters of the Neocomian sea, with the deposits of which their sediments were in part mingled, and under which they were finally buried.

The Chair was then taken by Prof. Prestwich, M.A., F.R.S., Vice-President.

3. "On *Pelanechinus*, a New Genus of Sea-urchin from the Coral Rag." By W. Keeping, Esq., B.A., F.G.S., Professor of Geology in the University College of Wales.

In 1855 an Echinid was described by Dr. T. Wright, from very fragmentary specimens, under the name of *Hemicidaris corallina*. Since that date two very fine specimens have been obtained, both from Calne, one by Mr. Keeping, sen., now in the Woodwardian Museum, Cambridge, the other in Dr. Wright's Collection. These show the affinities of the Echinid to be rather with the Echinothuridæ. The author regards this species as the type of a new genus, which he names *Pelanechinus*, and characterizes as follows:—

*Test* thin, circular, depressed, consisting of (1) transversely elongated coronal plates, (2) apical plates, (3) an actinal system of imbricating plates around the mouth. *Interambulacral areas* narrow at poles, but rapidly broadening towards the equator, with 6–8 rows of primary tubercles; the plates narrow, contour rounded, slightly undulating. *Ambulacral areas* more uniform, equal to $\frac{1}{3}$ of the greatest breadth of interambulacral areas, with two rows of primary tubercles; poriferous zones broad, pores trigeminal in the equatorial region. *Primary tubercles* rather small, smooth, perforated, uniform over both areas; spines small, hollow. *Peristome* deeply notched. *Actinal area* about $\frac{2}{8}$ of whole test, covered with zones of large imbricating plates, with perforations and perforated tubercles. *Jaws* large and powerful.

This Echinid has a marked similarity of appearance to *Asthenosoma* (*Calveria*), and the author believes that it also had a flexible test.

4. "Remarks on *Saurocephalus*, and on the Species which have

been referred to that Genus."[1] By E. Tulley Newton, Esq., F.G.S., of H.M. Geological Survey.

In this paper the author gives an account of those species of fossil fishes from American and British Cretaceous strata which have been referred to the genus *Saurocephalus,* originally founded by Harlan in 1830, and regarded by him as showing Reptilian affinities. The ichthyic nature of the species first described, *S. lanciformis,* Harl., was demonstrated by Prof. Owen. By Agassiz and Dixon certain large fossil teeth from the White Chalk of Lewes were identified with *Saurocephalus lanciformis;* and the latter also figures an elongated rostrum as belonging to this fish. Dr. Leidy, in 1856, re-described the original specimen of *Saurocephalus lanciformis,* and maintained that the jaws and teeth figured by Dixon do not belong to the genus *Saurocephalus;* he proposed for them the new name of *Protosphyræna ferox.* He thought also that the rostrum figured by Dixon belonged to a Sword-fish, and named the species *Xiphias Dixoni.* Specimens since obtained by Prof. Cope in America have proved that the rostrum and teeth actually belonged to the same fish, for the reception of which and of some American species Prof. Cope established the genus *Erisichthe.* The author maintains that Dr. Leidy's name, *Protosphyræna,* must be adopted for this genus, which will include the British *Protosphyræna ferox* (= *Erisichthe Dixoni,* Cope) and the American species, *P. angulata, anitida, penetrans,* and *ziphioides* (Cope). The characters of these species are discussed by the author. The species known on the Continent as *Saurocephalus albensis* and *influens,* Pict. et Camp., *S. dispar,* Héb., and *S. inæqualis* and *substriatus,* Münst., are founded on isolated teeth, and their affinities are regarded by the author as doubtful. *Saurodon Leanus,* Hayes, from the Greensand of New Jersey, belongs to *Saurocephalus,* which also includes a species described by Prof. Cope under the name of *S. arapahovius.* Teeth erroneously referred by Agassiz to *Saurodon Leanus* were regarded by Dr. Leidy as representing a new genus and species, *Cimolichthys levesiensis,* and to this last-named genus the author refers *Spinax marginatus,* Reuss, and, doubtfully, *Saurocephalus striatus,* Ag.

5. "A Microscopical Study of some Huronian Clay-slates." By Dr. Arthur Wichmann.

Although a considerable amount of attention has been devoted during recent years to the microscopical study of clay-slates and slate-clays, yet in none of the published researches on this subject has any account of the structure of the clay-slates of Archæan age been given. The author has availed himself of the extensive series of Huronian clay-slates collected by Major T. V. Brooks in the country around Lake Superior to supply this deficiency. The succession and relation of the rocks described have been fully treated of in the work of Hermann Credner and the publications of the Geological Survey of Michigan.

The chief object of the author is to discuss the origin of the crys-

[1] On this genus see a paper by Mr. W. Davies, F.G.S., in the Geol. Mag. 1878, for June last, p. 254, Pl. VIII.

talline constituents in clay-slates, and at the outset he describes in detail the microscopical character of clay-slate, of novaculite or whetstone, and of carbonaceous shales and slates respectively, dwelling more especially on the crystallized minerals which can be detected in each of these rocks, and the nature of the isotropic groundmass which sometimes surrounds them. He then points out that three theories have been advanced to account for the presence of these crystalline constituents in clay-slates. According to the first of these theories, the crystals in question are regarded as the product of chemical action in the ocean in which the original material was deposited. The second theory attributes the formation of the crystalline minerals to processes of metamorphism which have taken place subsequently to the solidification of the rocks. The third theory refers them to aggregative action going on in the still plastic clay-slate mud prior to its solidification. The first of these theories has been maintained by G. R. Credner, but against it the author adduces numerous arguments, and especially points out the difficulty of supposing an ocean capable of depositing from its waters at successive periods minerals of such different chemical composition as chlorite, actinolite, etc. In opposition to the second theory, which has received the support of Delesse, the author points out the existence in the rocks in question of broken crystals, which have been recemented by the surrounding clay-slate substance. The author is thus led to incline towards the third theory, in favour of which some striking facts, drawn from the microscopical structure of the rocks, have already been adduced by Zirkel. He admits, however, that later metamorphic actions are not to be excluded in seeking to account for the origin of the crystalline constituents of clay-slates, and points out that four distinct stages must be considered in the series of changes by which the rocks in question have acquired their present character:—1st, the deposition of the mud; 2nd, the formation of minerals during the plastic state; 3rd, the separation of materials during solidification; and 4th, the action of metamorphic processes.

6. "On a Section through Glazebrook Moss, Lancashire." By T. Mellard Reade, Esq., F.G.S.

The section described has been exposed in a cutting made by the Wigan Junction Railway. The moss rests on an almost perfectly level floor of Boulder-clay, and is at the deepest part about 18 feet thick. In the 3 or 4 feet at the base are branches, etc., of trees, and the stools are found resting on and rooted in the Boulder-clay; these are of oak or birch. Prostrate trunks were found, one, an oak, being 46 feet long and 3 in diameter. The surface of the clay is about 60 feet above O.D. The author thinks the section shows that the moss originated from the decay of the forest, favoured by change of climate, and gradually extended itself from the centre outwards, trees within it at the outer part being much less discoloured than those further in. In the latter part of the paper some cuttings and borings in the clays and sands are described, and the asserted occurrence of the trunk of a tree in the Boulder-clay is noticed.

7. "On the Tertiary Deposits on the Solimões and Javary Rivers

in Brazil."[1] By C. B. Brown, Esq. With an Appendix by R. Etheridge, Esq., F.R.S., F.G.S., and communicated by him.

The author in 1874 had the opportunity of examining some beds on the Solimões, or Upper Amazon, and the Javary, one of its tributaries, containing fresh- and brackish-water shells similar to those found in Tertiary deposits at Pebas, still higher up the river. The author indicates certain errors into which he considers previous writers to have fallen, and calls attention to the great extent of these beds, now demonstrated to occupy a tract of country 300 miles in length by 50 miles in breadth, and to the enormous change in the physical features of the region which must have taken place since their deposition. When this took place, the sea reached probably 1500 miles west of its present shore-line, covering the country which is now the valley of the Amazon. The absence of examples of false-bedding in the deposits leads him to the conclusion that they were formed in comparatively still water, into which flowed numerous streams bearing much vegetable matter, which has served for the formation of lignitic deposits, the whole being probably the upper beds of a series deposited under similar conditions to those of deltas in the present day. In an Appendix, Mr. Etheridge notices the fossils collected by the author, which included seeds of *Chara*, and species of *Mytilus* (1 new), *Anisothyris* (4, 1 new), *Lutraria* (1), *Thracia* (1), *Anodon* (1), *Unio* (1) *Natica?* (1), *Neritina* (2 new), *Odostomia* (1), *Hydrobia* (1 new), *Isæa* (1), *Dyris* (1), *Assiminea* (1 new), *Fenella* (1), *Cerithium* (2 new), *Melania* (4 new), and a new Gasteropod constituting a genus (*Alycæodonta*) allied to *Alycæus*. A single palatal plate of *Myliobatis* or *Zygobatis* (probably derived) was also found.

8. "On the Physical History of the English Lake-district, with Notes on the Possible Subdivision of the Skiddaw Slates." By J. Clifton Ward, Esq., Assoc. R.S.M., F.G.S.

The author traces the physical history of the lake-district from the commencement of the period when the Skiddaw slate was deposited. To this succeeded the volcanic Borrowdale series, which is followed after a physical break by the Coniston Limestone. Between this and the succeeding Silurian deposits there is little, if any, break. Thus, in the Lake-district, the break between Upper and Lower Silurian is physically below the Coniston Limestone, though palæontologically it is above it.

The Old Red Sandstone period was one of denudation, which was continued into the Carboniferous period; and perhaps the whole district was actually covered by the sea during the maximum depression of the Lower Carboniferous epoch. Since then it has probably never been submerged, but exposed to continuous subaerial denudation. The physical significance of the Mell Fell (Lower Carboniferous) conglomerates receives special attention.

The author, from consideration of the amount of deposition and rate of denudation, attempts to estimate the period which has elapsed since the commencement of the record, and sets it down

[1] On this subject see paper by Dr. H. Woodward, in Ann. & Mag. Nat. Hist. 1871, ser. 4, vol. vii. pp. 59 and 101, pl. v.

as 62,000,000 of years. He then considers the age of the Skiddaw slates. From lithological resemblances he is led to correlate the Skiddaw grit with the basement grit in the Welsh Arenig series, and thus to regard the beds below the grit as the equivalent of the Tremadoc, and perhaps of part of the Lingula Flags.

The palæontological evidence for the correspondence of the Arenig series with the whole of the Skiddaw slates rests chiefly on Graptolites and Trilobites. The author holds that the evidence from the former is inconclusive, and that from the latter to some extent contradictory, so that the physical evidence can in no way be overridden by it.

9. "On some Well-defined Life-zones in the Lower Part of the Silurian (Sedgw.) of the Lake-district." By J. E. Marr, Esq. Communicated by Prof. T. M'K. Hughes, M.A., F.G.S.

This paper treats of the zones of fossils occurring between the Coniston Limestone and Coniston Grits, with a view of establishing a boundary between the Cambrian and Silurian formations. In the lake-district beds the genus *Phacops* is very abundant, one or more species of its subgenera characterizing each fossiliferous formation. The zones thus indicated are found to hold good when the organic remains as a whole are considered. The author separates the Ashgill shales from the Coniston Limestone, giving separate lists of fossils to show the palæontological difference, from which it appears that but few (and those the very common Bala fossils) are common to both, while the most characteristic Ashgill fossils do not occur in the Coniston Limestone. They indicate that the Ashgill formation is Upper Bala. It is very irregular in thickness, and the author thinks this due to an unconformity above the Ashgill beds. Here the author agrees with Prof. Hughes in placing the base of the Silurian. He gives lists of the fossils in the basement bed and the Stockdale Shales, and points out that their facies is distinctly Silurian. Very few fossils are common to them and the Coniston Limestone or Ashgill Shales. Hence there is here both a physical and a palæontological break, so that the division between Cambrian and Silurian should be placed at this horizon. A detailed description (with lists of fossils) is given of the Coniston Flags and Coniston Grits. An appendix contains some palæontological notes on some species of the genus *Phacops*.

10. "On the Upper Part of the Bala Beds and Base of Silurian in North Wales." By F. Ruddy, Esq. Communicated by Prof. T. M'K. Hughes, M.A., F.G.S.

The author describes a series of sections in the upper part of the Bala and the succeeding beds, and gives lists of fossils. Details of the various beds between the Bala and Hirnant Limestone are given, above which come soft blue shales underlying Tarannon shales, when fossils cease until the base of the Wenlock is reached. The author has been able to trace the Hirnant Limestone and grit considerably beyond the limits of the Hirnant valley. The sections at Cynwyd (to the west of Corwen) are described. Here occur the equivalents of the Bala Limestone and beds above this up to the level (probably) of the Hirnant Grit.

## CORRESPONDENCE.

### *ARBUSCULITES ARGENTEA*, MURRAY.

Sir,—Though unable to refer to Murray's description of this fossil, the quotations given from it by Mr. R. Etheridge, jun., in the June Number of the Magazine, p. 269, recalled at once to my mind the characters of a somewhat similar fossil I discovered some years since in rocks of Lower Carboniferous age at Arsaig in Nova Scotia. On the shore at this place, near McAras Brook, there are exposed beds of a dark, Oolitic limestone, which, in places, are interpenetrated in all directions with bright glistening threads "resembling broken bits of silver-wire." These occur in curved fragments of about two or three lines in length and about one-tenth of a line in thickness; they are solid, and, so far as I can see, neither grooved nor branched, and in these respects they differ from the forms described by Murray.

The only other fossils visible in the same beds are very poorly preserved casts of *Producti*; their presence supports the opinion expressed by Mr. Etheridge that these glistening threads are merely the long spines of this Brachiopod; but if this is the case, it is very peculiar that, whilst the shells of the *Producti* have to a large extent disappeared, their spines should have been preserved in such great numbers and such perfect condition. On this supposition too, it is remarkable that similar spines (?) should not have been noticed in limestones in which *Producti* abound, for in the beds mentioned they are very conspicuous objects. Inclosed are two small pieces of the rock, showing these spines (?). On one is what appears to be the expanded base of attachment. Geo. Jennings Hinde.

Toronto, *June*, 21*st*, 1878.

### AGE OF THE ROCKS OF MONTE GENEROSO.

Sir,—I have several times had the pleasure of ascending Monte Generoso, a mountain easy of access, which lies between the Lakes of Como and Lugano, and from which one of the finest views on the continent is obtainable. After winding up through chestnut woods from Mendisio for some four miles, the pathway ascends a somewhat steep incline in zigzags. The rocks here are remarkably white and dazzling and might be almost mistaken for chalk. For some 40 ft. or more below, they are coloured red, similar to the Red Chalk in Yorkshire.

On the last occasion of my visit, I met with a French geologist at M. Paston's Hotel near the summit, and from him I obtained some information about these rocks which had excited my curiosity, but not enough to satisfy me as to their position relative to English strata. He classed them as follows:—

JURA LOMBARD.

*Majolique*
*Calcaire rouge*
*Calcaire grès*
*Calcaire noir*

*Conglomerat Marneux*

Can you, or can any of your readers give me some more information on this subject? EDW. MAULE COLE.

WETWANG VICARAGE, YORK.

P.S.—Can you recommend to me any notices on "Red Chalk" in England?—E. M. C.

The Rev. E. M. Cole will obtain the information he seeks, by consulting the following papers, which are picked out of a list still in course of formation.

Blake, Rev. J. F.—Proceed. Geol. Assoc. vol. v. p. 232, etc.
Judd, J. W.—Quart. Journ. Geol. Soc. vol. xxiii. p. 227.
Phillips, Prof. J.—Geol. of Yorkshire, 3rd edit. p. 75.
Seeley, Prof. H. G.—Ann. and Mag. of Nat. Hist. 3rd series, vol. vii. p. 233, 1861; Quart. Journ. Geol. Soc. vol. xx. p. 327.
Taylor, Richard.—Phil. Mag. 1823, vol. 61, p. 81.
Wiltshire, Rev. T.—Quart. Journ. Geol. Soc. vol. xxv. p. 185.

For Analysis of Red Chalk see—

Church, A. H.—Chemical News, vol. 31, p. 199; or GEOL. MAG. Vol. II. p. 331.

B. B. W.

## OBITUARY.

### THE REV. WILLIAM BRANWHITE CLARKE,

M.A., F.R.S., F.R.G.S., F.G.S., ETC.

BORN 2 JUNE, 1798. DIED 17 JUNE, 1878.

WE regret to record the death of another veteran geologist, the "Father of Australian Geology," the Rev. W. B. Clarke, which took place at his residence near Sydney, in the eighty-first year of his age. Mr. Clarke was born at East Bergholt, Suffolk, on the 2nd June, 1798, and was partly educated at Dedham Grammar School. He entered Cambridge in 1817, becoming a member of Jesus College, took his B.A. in January, 1821, and became M.A. and Member of Senate in 1824.

From 1821 to 1824 he acted in his clerical capacity at Ramsholt and other places, and during this period made fifteen distinct geological and other excursions on the Continent, in addition to those prosecuted by him in this country. During the years 1830–31 Mr. Clarke was present at many of the scenes of the Belgian War of Independence, and the last siege of Antwerp. His clerical duties were continued up to the year 1839, when he left for New South Wales, with the object of examining the physical structure of the country, and regaining health lost during a severe illness. From the time of his arrival till 1844, Mr. Clarke was in clerical charge of the country from Paramatta to the Hawkesbury River, and for a portion of the time conducted the King's School. In that year he undertook the charge of Campbelltown, but in 1847 he became minister of Willoughby, which he held till 1870, then retiring, after nearly fifteen years' service in the church, with a testimonial from his parishioners, expressive of their sympathy and respect.

Mr. Clarke's literary labours were numerous and varied. In 1829 a series of poems and translations were published, entitled "Lays of Leisure," in 1819 a poem, entitled "Pompeii," in 1822 "The River Derwent, and other Poems," and in 1828 "Recollections," a poetic commemoration of a visit to Mont Blanc; and other works of a religious nature. Mr. Clarke's valuable services to the Government commenced in 1840, when he made his first journey to the southward, through the Illawara district. The result of this, and his other journeys, geographical as well as geological, will be found recorded in a clear and concise manner in his chief work,[1] and in the various Parliamentary Blue Books[2] published by Authority, to say nothing of the fifty-three papers accredited to his name in the Catalogue of Scientific Papers[3] of the Royal Society. In addition to the list there given, we are acquainted with many others, and it may be mentioned that some of Mr. Clarke's most interesting communications were made to the leading Sydney newspaper, the *Sydney Morning Herald,* which we regret are not preserved in a more lasting form.

Mr. Clarke's labours as a geologist and zoologist commenced some time before his departure from this country, for in 1828 a paper, "On the Construction of Geological Hammers," appeared, and again in 1837, "On the Geological Structure and Phenomena of Suffolk, and its Physical Relation with Norfolk and Essex," with several others. One of his first papers on Australian geology was, we believe, "On the Occurrence of Atmospheric Deposits of Dust and Ashes; with Remarks on the Drift Pummice of the Coasts of New Holland," in 1842.

With the 'Discovery of Gold in Australia,' and the 'Age of the N. S. Wales Coal-beds,' the name of W. B. Clarke will always be associated. This is not a fitting time to enter into the merits of his controversies respecting his claim for priority to the former, or his views on the latter question; let it suffice, however, that excepting Count de Strzelecki, the palm has been awarded him in the Gold question by Prof. Geikie, F.R.S., in a late work,[4] whilst the second may, to a certain extent, still be said to remain an open question. Some of the more important subjects which engaged Mr. Clarke's attention were the occurrence of gold in granite, the occurrence of the diamond in N. S. Wales, and the discovery of tin in Australia. The occurrence of the diamond appears to have been known to Clarke as early as September, 1859; whilst under this head may be mentioned a most exhaustive and critical paper, the Natural History of the Diamond, delivered in the form of two Anniversary Addresses to the Royal Society (N. S. Wales) on the 25th May, 1870, and 22nd May, 1872, respectively. Little doubt appears to exist that we owe

[1] Researches in the Southern Goldfields of New South Wales. 2nd ed. 8vo. Sydney.

[2] Papers relative to the Discovery of Gold in Australia, presented to both Houses of Parliament, by Command of Her Majesty. Parl. Blue Books. Folio. London.

[3] Catalogue of Scientific Papers, Royal Society, vol. i. 1867; vol. vii. 1877.

[4] Life of Sir Roderick I. Murchison, Bart., K.C.B., etc., by Archibald Geikie, LL.D., F.R.S., etc. London, 1875. Two vols. 8vo. (vol. ii. p. 135).

the first actual discovery of tin in Australia to Mr. Clarke, as detailed by himself in a paper 'On Mining' contributed to the *Sydney Morning Herald*, August 16th, 1849. He also reported on the occurrence of Cinnabar in N. S. Wales, and, by means of a collection of fossils, made with the assistance of W. Hardy, Esq., first elicited the fact of the occurrence of rocks of Silurian age on the flanks of the Dividing Range, a discovery for which he was highly complimented by the late Sir R. I. Murchison. This collection was examined and determined by the late Messrs. Lonsdale and Salter, but a second and more extensive one, gathered from all parts of N. S. Wales by Mr. Clarke, and his friends, has lately formed the subject of a detailed and successful work by Prof. de Koninck.[1]

Mr. Clarke paid a geological visit to Tasmania in 1856, and another in 1860, to examine the country around Fingal and the Don River. The interest he took in all matters connected with Colonial Geology cannot be better shown than by the fact that he successfully recommended no less than three Government Geologists to their respective colonies, viz. the late Messrs. R. Daintree, and C. D'Oyly H. Aplin, to North and South Queensland, and Mr. C. Gould to W. Australia, who was succeeded by Mr. H. Y. L. Brown. We believe Mr. Clarke was also instrumental, at all events to a considerable extent, in the appointment of Mr. C. S. Wilkinson, F.G.S., Government Geologist for N. S. Wales. Just as he took an interest in Colonial Surveys, so Intercolonial Exhibitions appear to have occupied much of his time, taking particular interest in the Geological Sections, and frequently contributing articles to the official catalogues on the resources of his adopted country. He was a member of the N. S. Wales Commission of the Paris Exhibition of 1867, the Intercolonial Exhibition of 1870, and the Philadelphia International of 1877. The Rev. W. B. Clarke was appointed in 1839, by Sir G. Gipps, a Trustee of the Australian Museum, Sydney, and of the Free Public Library. Sir C. Fitzroy placed his name on the first list of Fellows of Sydney University, an honour, however, never accepted, we believe. The Presidential and Vice-Presidential chairs of the Royal Society of N. S. Wales were several times filled by Mr. Clarke; indeed in the reconstitution of that Society, a short time since, he took a most lively interest. The Geological Society of London elected him a Fellow in 1826, and awarded him the Murchison Medal in 1877, "in recognition of his remarkable services in the investigation of the older rocks of New South Wales." By the Royal Geographical Society he was elected a Fellow in 1865, and his name is to be found amongst the list of members of the Société Géologique de France, and the Corr. Members of other Continental Societies. Mr. Clarke was elected a Fellow of the Royal Society in June, 1876, for "the important part taken (by him) in the refounding of the Royal Society of N. S. Wales, and in the promotion of Scientific Knowledge in the Colony." We believe Mr. Clarke was engaged, only shortly before the com-

[1] Recherches sur les Fossiles paléozoiques de la Nouvelle-Galles du Sud (Australie). Par L. G. de Koninck, D.M. Bruxelles (2 vols. 8vo. pt. 1, text and atlas, 1876; parts 2 and 3, text and atlas, 1876–77).

mencement of the attack which resulted in his death, on a Geological Map of N. S. Wales, and on a second edition of his "Southern Gold Fields." The name of W. B. Clarke requires no encomiums from us; but when we say, as we think we may safely do, that more than half his papers and reports have been written with the view to the development of the mineral resources of his adopted country and the well-being of his fellow-colonists, some idea may be gathered of the debt N. S. Wales owes to the memory of the Rev. W. B. Clarke. Few are aware of the immense amount of work performed during his various explorations, but it is stated that he has officially reported on no less an area than 108,000 square miles of territory.—R. E., jun.

[For some of the facts connected with the earlier career of the Rev. W. B. Clarke we are indebted to extracts from an Australian contemporary.]

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## THOMAS OLDHAM, A.M., LL.D., F.R.S., F.G.S.,

### LATE DIRECTOR OF THE GEOLOGICAL SURVEY OF INDIA.

BORN MAY, 1816, DIED 17 JULY, 1878.

DEATH has just deprived us of another well-known and eminent geologist, who was the founder of and for twenty-five years occupied the arduous and important post of Superintendent of the Geological Survey of our Indian Empire, probably the greatest geological undertaking carried on by the British Government.

Dr. Oldham was the eldest son of the late Thomas Oldham, Esq., of Dublin, in which city he was born in May, 1816, and where he was educated at a private school, and entered Trinity College, Dublin, before he was sixteen years of age.

After obtaining his B.A., he devoted 1837–38 to special studies of engineering in Edinburgh, where he also applied himself to acquiring a sound knowledge of geology and mineralogy under Prof. Jamieson, with whom he formed a life-long friendship. Subsequently he was engaged in some extensive engineering works in Edinburgh.

Returning to Ireland in 1839, he became principal Geological Assistant to General (then Captain) Portlock, R.E., at that time in charge of the Geological Department of the Ordnance Survey of Ireland, and with whom he surveyed the counties of Derry and Tyrone, and was largely engaged in the preparation of the report on those counties, published in 1843. Subsequently he became Curator and Assistant Secretary to the Geological Society of Dublin, and Assistant Secretary to the Institute of Civil Engineers of Ireland.

In 1844 he was appointed Assistant-Professor of Engineering in Trinity College, Dublin, under Prof. J. MacNeill. In 1845 he succeeded Prof. Phillips to the chair of Geology in Dublin University. In 1846 he became Lecturer to, and in 1848 President of, the Geological Society of Dublin.

Between 1844 and 1849 he communicated no fewer than twelve papers to the "British Association" and the "Dublin Geological Society's Journal," all bearing on Irish Geology and Palæontology. On 1st July, 1846, he was appointed Local-Director for Ireland of the

Geological Survey of the United Kingdom, which he held until 14 Nov., 1850, when he was nominated to the charge of the Geological Survey of India by the Hon. the Directors of the East India Company, arriving in Calcutta early in 1851.

Those of our readers who are acquainted with the climate, the physical features, and the vast territorial extent of our Indian Empire, will more readily appreciate the onerous responsibility undertaken by Dr. Oldham to inaugurate and set in motion the machinery for so large and important a department of the Indian Civil Service.

With only a small staff of about twelve assistants he set resolutely to work, and at the end of ten years from the commencement of the Survey he was able to show an area, carefully mapped and coloured geologically, more than twice the extent of the whole of Great Britain, principally in Bengal and Central India.

One of the chief objects of the Director was to ascertain, by careful examination and mapping, the extent of the Indian Coal-measures and the quality of the Coal. The best appears to be the Assam Coal, which lies near the river Brahmapootra; but extensive fields of coal exist, though by no means distributed generally over the Indian Empire, but almost entirely concentrated in a double band of coal-yielding deposits, which, with large interruptions, extend more than half-way across India, from near Calcutta towards Bombay.

In 1867 Dr. Oldham presented an elaborate Report to the Secretary of State for India, "On the Coal Resources of India," but no fewer than sixteen separate memoirs on the various Coal-fields have been published in the "Memoirs," with Maps, viz.:—

1. On the Coal and Iron of Cuttack.
2. On the Structure and Relations of the Talcheer Coal-field.
3. On the Rânigunj Coal-field.
4. On the Coal of Assam.
5. The Jherria Coal-field.
6. On the Bokaro Coal-field.
7. On the Ramgurh Coal-field.
8. Kurhurbârí Coal-field.
9. Deoghur Coal-field.
10. Karanpûrâ Coal-fields.
11. The Ítkhûrí Coal-field.
12. The Daltonganj Coal-field.
13. The Chopé Coal-field.
14. The Sâtpurâ Coal-basin.
15. The Coal-fields of the Nâgâ Hills, bordering Lakhimpur and Sibsagar Districts, Assam.
16. The Wardha Valley Coal-field.

In 1862–64 he published, in conjunction with Prof. John Morris, M.A., a memoir, "On the Fossil Flora of the Rajmahal Series" (Memoirs Geol. Surv. India), illustrated by numerous plates of the Zamia-like plants occurring in these Plant-bearing beds.

In 1863 he communicated a paper to the Geological Society of London, "On the Occurrence of Rocks of Upper Cretaceous Age in Eastern Bengal."

A grand feature of the Geological Survey of India is its publications, which, under Dr. Oldham's administration, had attained to an extent and importance unsurpassed even by the magnificent volumes issued by the United States Surveys, and distributed with the same liberality.

These publications are of four kinds, viz.:—

1. *Annual Reports*, commenced in 1858.
2. *Records*, issued quarterly, containing brief reports and papers forming abstracts of more detailed work, and notices of recent discoveries, etc. Royal 8vo. About 11 volumes published, commenced in 1868.
3. *Memoirs*, in royal 8vo., illustrated by Plates and coloured Maps of the several districts, of which 14 volumes have appeared, commenced in 1859.
4. The *Palæontologia Indica*, being figures and descriptions of the Organic Remains obtained during the progress of the Geological Survey of India. Eleven separate series published.

Being in England in 1867, Dr. Oldham attended the Meeting of the British Association at Dundee, and presented an elaborate Report on the Geology of India.

Dr. Oldham's last work, in connexion with the Geological Survey of India, was to complete the transfer of the very extensive collections and library from the former Indian Geological Survey Office to its new quarters in the large Imperial Museum of Calcutta, where they are now favourably located under the present able Superintendent, Mr. Henry B. Medlicott, M.A., F.R.S., F.G.S.

Dr. Oldham was chosen an M.R.I.A. in 1842.

He was elected a Fellow of the Geological Society of London in 1843; and of the Royal Society in 1848.

He was elected a Member of the Royal Asiatic Society of Bengal in 1857, serving fourteen years on the Council and four times elected its President. A bust of Dr. Oldham was obtained by its members and placed in the Society's rooms.

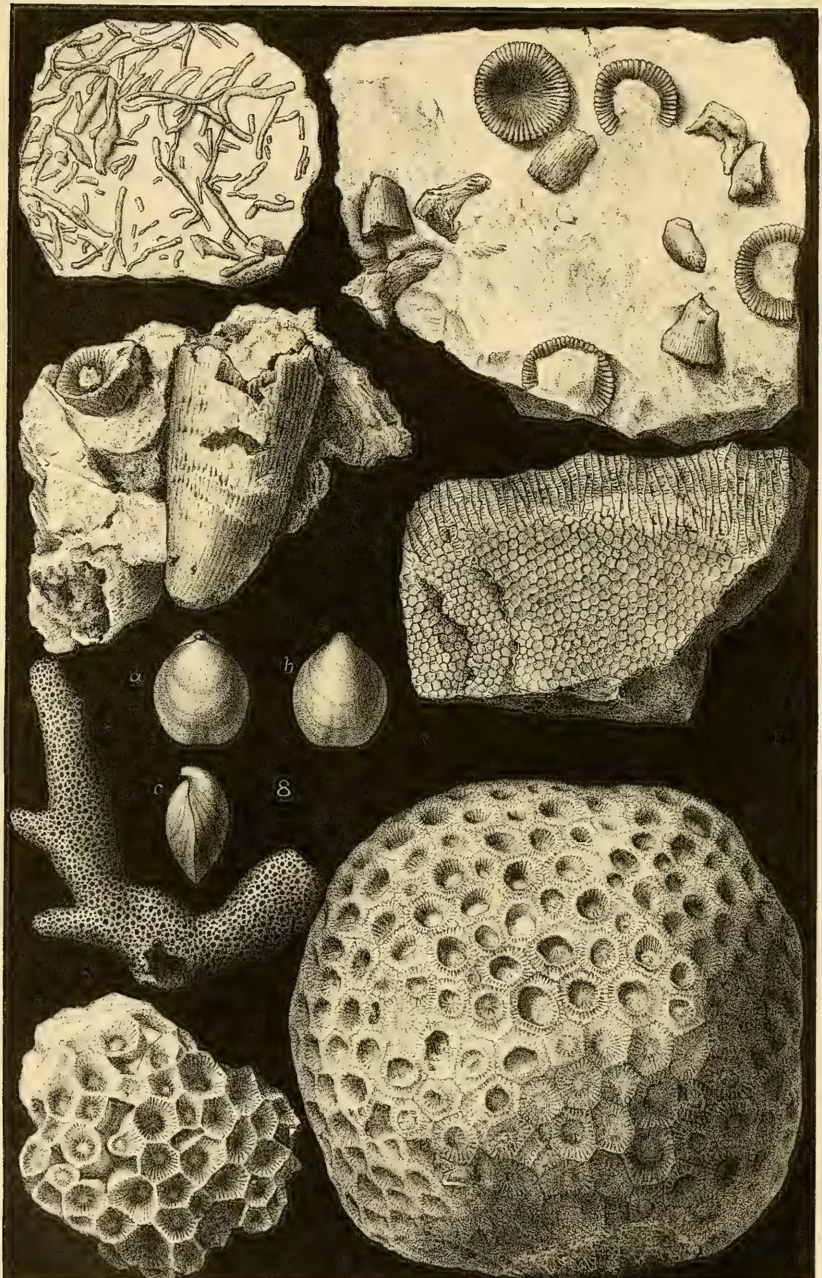
He received the Gold Medal of the Royal Society in 1875; the Emperor of Austria also presented him with a gold medal for his eminent geological labours in India.

He was an honorary or corresponding Member of the Imperial Academy and of the "Isis" Society of Dresden; of the Imperial Society of Naturalists, Moscow; of the Royal Geological Society of Cornwall; of the Geological Society of Edinburgh; and of the Zoological Society of London.

He was the discoverer in 1849 of *Oldhamia* in the Cambrian rocks of the Wicklow Hills, Ireland (named after him by Prof. Edward Forbes), the then oldest known fossil organic remain.

In 1850 he married Miss L. M. Dixon, daughter of William Dixon, Esq., of Liverpool, by whom he had five sons and one daughter.

Since Dr. Oldham's retirement from the post of Superintendent of the Geological Survey of India, he has resided at Eldon Place, Rugby. He was lately appointed Examiner in Geology to the University of London, and had fulfilled a similar office to the Indian Civil Service College at Cooper's Hill. His final illness was of brief duration, his last hours of active work being spent in reviewing Barrande's Cephalopoda of Bohemia, and F. V. Hayden's grand Geological and Geographical Atlas of Colorado, both of which will be found in the present Number. But the friendly hand that penned them did not live to correct the proofs. Adopting the words of one of his colleagues, we may truly say, that, "in Dr. Oldham's death we have to regret the loss of one who was a good man, a faithful friend, and a profound observer of Nature."




C.L. Griesbach del. W. West & Co. imp.

Arctic Fossils from Beechey Island, &c.

THE

# GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. V.

No. IX.—SEPTEMBER, 1878.

## ORIGINAL ARTICLES.

### I.—Notes on some Arctic Silurian or Devonian (?) Fossils from Beechey Island, brought home by the S.Y. "Pandora" in 1875, and from Port Dundas, Lancaster Sound, by an earlier Expedition in 1853.[1]

By Henry Woodward, LL.D., F.R.S., F.G.S.,
of the British Museum.

(PLATE X.)

I AM indebted to my friend, Mr. Thomas Crowther Brown, of Further Barton, Cirencester, for placing in my hands some time since certain Arctic Corals (brought home in 1853 or 1854[1]), for illustration, to be afterwards deposited in the Geological Department of the British Museum. Some time previously I had also received a small but interesting series of specimens from Beechey Island, collected by Dr. A. Horner, the Medical Officer to the S.Y. "Pandora" (Captain Sir Allen Young), and by the Artist to the Expedition, G. R. De Wilde, Esq.; these latter were collected in August, 1875.

I should not have undertaken to notice these myself but for the valuable aid kindly afforded me by my friend Mr. Robert Etheridge, F.R.S., and upon going into the Bibliography of these Arctic fossils, I found that the late Mr. J. W. Salter, Prof. Haughton, and others, had already noticed the greater part of them, and there is consequently little or no need to do more than follow in their steps.

In June the Geological Department of the British Museum was enriched by the collections made by Captain H. W. Fielden, R.A., F.G.S., and Dr. R. W. Coppinger, R.N., of H. M. S. "Alert" and "Discovery" (Captain Sir George Nares), and described by Mr. R. Etheridge.[2]

In July the Museum of Practical Geology transferred to the British Museum a series of specimens collected by Admiral Ommanney, R.N., Captain Austin, R.N., Dr. Sutherland, Captain Penny, and others in their Voyages to Wellington Channel in 1850–51 (in search of Sir John Franklin), and described by Mr. J. W. Salter, F.G.S., in Sutherland's Journal (Appendix to vol. ii. Plates v. and vi.); most of these are from Cape Riley and Beechey Island. There are also a number of fossils from Depôt Point, Albert Land, and

[1] Probably by some of the officers of the "Phœnix" (Captain Inglefield), which visited Beechey Island both in 1853 and 1854, making two summer trips, bringing back with her on the second voyage part of the "Belcher Expedition."

[2] See Mr. Etheridge's paper in Quart. Journ. Geol. Soc. 1878, vol. xxxiv. p. 568, plates xxv.–xxix.

Exmouth Island, besides several from Beechey Island brought home by Captain Sir Edward Belcher, C.B., 1852–54, and by Captain Inglefield (1853–54), described by Mr. Salter in the Appendix to "The Last of the Arctic Voyages" by Captain Sir E. Belcher, R.N. (London, 1855, vol. ii. p. 377, pl. xxxvi.).

Those from Albert Land, etc., are of Carboniferous age, consisting of Corals, Brachiopoda, etc., *Clisiophyllum, Zaphrentis, Syringopora, Fenestella, Spirifer, Productus* 2 sp., etc. Those from Cape Riley and Beechey Island, both sides of Wellington and Queen's Channel, Seal and Cornwallis Islands, are of Silurian age, and some few are perhaps Devonian.

Writing of Beechey Island, Dr. Sutherland observes:—"Geological specimens were obtained in great abundance. *Favosites, Catenipora, Cyathophyllum, Porites*, and Fucoid impressions were very common forms of organic remains. At Cape Riley, and also on Beechey Island, *Favosites gothlandica* was found almost everywhere in great abundance, but especially at the latter place, where it occurs *in sitû*."

1. *Strephodes? Austini*, Salter. Pl. X. Fig. 1.

Appendix to Sutherland's Journal of Captain Penny's Voyage to Wellington Channel in 1850-51. London, 1852. Geology by J. W. Salter, p. ccxxx., pl. 6, figs. 6, 6*a*. magnified.

"This fine coral (writes Mr. Salter), which we dedicate with great pleasure to the gallant commander of the Expedition, is one of the most frequent species. It occurs in the form of rounded masses from an inch to several inches in diameter, covered on all sides with stellate cells—at first sight looking very like the *Astreæ* of the present seas. The internal structure, however, as of nearly all the corals of the older rocks, is quite of another order. . . . Prof. M'Coy prefers to regard this as a *Clisiophyllum* rather than a *Strephodes* from the internal structure; it is, however, so imperfectly shown in the sections I was able to make, and the twisting of the lamellæ is so conspicuous, that I leave it here for the present."[1]

"Surface covered by hexagonal or pentagonal cells, of various sizes, the larger ones frequently four lines across, the smaller ones in groups of two, three or more, at the angles of the others. The extreme edges of the cups are thin and crenulated, their sides thickened and sloping steeply. In a large star they are radiated by about 30 or 40 equal blunt lamellæ, which extend to the base, and about half of them are there united in bundles of three or four, and are twisted upon the surface of a low boss which rises from the centre. The lamellæ are united everywhere by frequent vesicular plates. A transverse section below the cup shows narrow, but distinct, divisional walls between the cells, and the lamellæ twisted in the middle and united loosely by the vesicular tissue. The intermediate ones in the section appear shorter than they are in the cup. A longitudal section shows the vesicular plates arched a little upwards in the middle under the boss, then downwards, and again

[1] On a reconsideration of these Palæozoic Corals, probably it may be found possible to bring *Strephodes* and *Lonsdalia* near, or even to unite them together.

inclined upwards in the outer area in two or three rows of cells. In these sections both the lamellæ and the transverse plates are thin, and the former are wavy."

*Localities.*—Cornwallis, Beechey and Griffith's Islands.

Our specimen, Pl. X. Fig. 1, is from Beechey Island, and was collected and brought home by Dr. A. Horner, of the S.Y. "Pandora" (Capt. Sir Allen Young, R.N.). It is clearly a young example, the corallites not having increased by calycial gemmation many times, so as to form such a fine, evenly-rounded composite mass as that represented in Fig. 2.

With reference to the fine rounded composite Coral, Plate X. Fig. 2, I was greatly perplexed for some time, and was almost inclined to refer it to the genus *Acervularia*; but after a more careful examination, and by comparing it with numerous other specimens, I have been led to the conclusion that it is merely a *Strephodes Austini*, in which the extremely sharp crenulated edges dividing the calices from one another, which in young and unworn specimens (as in Fig. 1) stand boldly up in hexagonal or pentagonal lines, have been removed by weathering over the whole upper surface, exposing thereby the lower wall of the calices where they are thickened by the septal radii and strengthened by numerous interseptal dissepiments. The sides of the calices are in some instances worn down to a level with the columella, giving the Coral the appearance of a well-(*acid*-)developed *Acervularia luxurians* from Dudley; but this is deceptive, for on examining the margins of the specimen, the dividing ridges between the calices are seen nearly as well preserved as in Fig. 1, changing entirely the character of the specimen. Several similar rounded masses are in Sutherland's Collection from Beechey Island, etc. This specimen is interesting as having been brought from Port Dundas, which, like Cape Riley, is on the South Coast of N. Devon, but 200 miles to the Eastward, on the N. shore of Lancaster Sound, Lat. 75° N. It was presented to the British Museum by Thomas Crowther Brown, Esq. Probably brought home by one of the crew of the "Phœnix" (Capt. Inglefield), 1853–54.

2. *Favosites polymorpha*, Goldf. Pl. X. Fig. 3.

Goldfuss, Petrefacta Germaniæ, t. 27, fig. 2–4.

*Favosites cervicornis*, and *F. dubia*, Edw. Arch. Mus., and Edw. and Haime, Brit. Foss. Corals, t. 48, fig. 2.

Appendix to Sutherland's Journ. (Geology), by J. W. Salter, p. ccxxviii. pl. 6, figs. 9 and 9*a*. magnified.

Mr. Salter writes: "Well-preserved specimens are frequent; and both the polymorphous (fig. 9) and branched varieties are found at Griffith's Island.

"The tubes are by no means of equal size,—numerous small ones occurring between the others. The edges are somewhat thickened. Internally the tubes are sometimes cylindrical and smooth, at others more prismatic. They are sometimes faintly striated inside. The pores occur in single rows at wide distances apart. The transverse diaphragms are not visible in these specimens." Mr. Salter alludes also to another specimen which agrees well with the *F. crassa* of M'Coy.

*Localities.*—Griffith's Island, Cape Riley and Beechey Island. Leopold's Island (frequent).

Fig. 3 was obtained by Dr. Horner of the S.Y. "Pandora" from the shore of Beechey Island, August 25, 1875.

3. *Favosites Gothlandica*, Linn. sp. Pl. X. Fig. 4.

*Corallium Gothlandicum*, Linn., *Calamopora Gothlandica*, Goldf. Petref. Germ. t. 26, fig. 3, and *C. balthica*, fig. 4.

This is a very common species, having been brought home by Dr. Horner ("Pandora"), and also by Captains Austin of the "Resolute," and Ommanney of the "Assistance," and by Captain Penny. Mr. Salter finds it to be quite identical with Goldfuss's figure.

"On the same specimens," he writes,[1] "a single or double alternating row of pores may be seen on each face and the distance between the transverse partitions (diaphragms) varies much; in the same tube we have, within a very short distance, 5, 4, 3, 2, and 1½ diaphragms in the space of one diameter. The columns also vary much in size."

*Localities*—Griffith's, Cornwallis, Leopold and Beechey Islands, very widely distributed.

4. *Cyathophyllum? Pickthornii*,[2] Salter, sp. Pl. X. Figs. 5 and 6.

*Strephodes Pickthornii*, Salter, Sutherland's Journal, vol. ii., Appendix, p. ccxxx. plate 6, fig. 5.

In MM. Edward's and Haime's Monograph on British Fossil Corals, p. 232, the authors observe: "We are inclined to consider the *Strephodes gracilis*, of M'Coy, as belonging to the genus *Cyathophyllum*." We cannot but think that *Strephodes Pickthornii* should also be referred to that genus. From a large number of specimens examined by us in the Arctic collections already mentioned, it certainly does not affect the mode of aggregate or composite growth attributed to *Strephodes*; all the individuals being found growing distinct even when placed closely together in the same rock-mass.

Mr. Salter describes this species as follows: "The tube is short, conical, and longitudinally striated; sometimes annulated and rugose in growth: and it grows rapidly in breadth,—in the length of an inch and a half attaining an inch in diameter. The cup is very deep, its sides formed of about 56 narrow lamellæ of equal size, connected by cross-bars, which are the edges of vesicular plates. Half of these lamellæ stop short at the bottom of the cup, but the rest cross a shallow depression, and are then twisted a little into bundles, and united on the crown of a low boss, which is not nearly elevated enough to constitute it a *Clisiophyllum*. At first sight the coral looks like a *Petraia*,[3] but the vesicular plates between the numerous lamellæ removes it from this genus."

*Localities.*—Cape Riley and Beechey Island, Griffith's and Cornwallis Islands.

Fig. 5 on Plate X. was obtained by G. R. De Wilde, Esq. (of the "Pandora"), at Beechey Island, in 1875, and is now in the British

[1] Appendix to Sutherland's Journal, p. ccxxviii.

[2] Named after Mr. Pickthorne, surgeon of the "Pioneer."

[3] Some of the specimens marked *S. Pickthornii* may belong to a species of *Petraia;* they are, however, too much weathered to be safely determined.

Museum. Fig. 6 is a larger but much weathered specimen from Port Dundas, N. Devon, lat. 75°, 200 miles to the East of Cape Riley. This specimen was presented to the British Museum by Thomas Crowther Brown, Esq., of Cirencester.

In many of these corals, which have been partially silicified, the limestone has frequently been dissolved out, leaving cavities in the fossils.

5. *Alveolites ? arctica*, sp. n., H. Woodw. Pl. X. Fig. 7.

This small ramose coral occurs in considerable abundance in the shaly limestone of Beechey Island; but few specimens have the calices preserved, and they are more widely separated than in *Alveolites ? seriatoporoïdes*, Edw. & H.

The specimen, a part of which has been drawn on our Plate (Fig. 7), is covered on both surfaces with the small branching stems of this Alveolite, and the transverse section shows the interior of the rock to be similarly crowded.

Stems, mostly cylindrical, about 1 mm. in diameter, pores about 2 in every mm. Some of the branches have annular constrictions, giving them in places a slightly moniliform appearance; terminations of branches rounded. The tendency to ramify is not greatly developed in this form, although many of the stems have well-marked branches exposed.

These specimens (like nearly all the Arctic fossils I have seen) have long been exposed to atmospheric influence in the cliffs, and consequently present a smoothed appearance.

*Locality.*—Beechey Island, brought home by Dr. A. Horner of the S.Y. "Pandora."

6. *Atrypa phoca*, Salter, sp. Pl. X. Fig. 8 (young state).

*Rhynchonella phoca*, Salter. Appendix to Sutherland's Journal, 1850-51. London, 1852, Geology by J. W. Salter, p. ccxxvi. pl. v. figs. 1, 2, 3. Variety of *T. subcamelina*, De Vern., Geol. Russ., vol. ii. pl. 9, fig. 4.

*Atrypa phoca*, Salter, sp. Haughton, Description of Fossils accompanying Capt. Sir Leopold M'Clintock's Reminiscences of Arctic Ice-Travel in Search of Sir John Franklin, Proc. Roy. Dublin Soc., 1856, vol. i. p. 240, pl. v. figs. 3, 4, 7.

Prof. Haughton, writing on this species (*op. cit.*), says:—"This is the *Rhynchonella phoca* of Salter. I have ventured to place it under the genus *Atrypa*, as I cannot find any trace of an aperture in or under the beak." I insert Mr. Salter's description, altering only the genus:—

"*Description.*—Rounded, globose, valves longer than broad, their greatest breadth at about the middle of the shell, thence becoming rapidly narrower towards the front, which is somewhat truncated. Valves equally convex in middle age; in old specimens the smaller one rather gibbous near the beak, but not raised into a ridge. Beak small but prominent, incurved in full-grown specimens. Front not at all raised, but indented by a broad, shallow sinus. The large valve has a distinct narrow median sulcus in the depression. Surface concentrically striated, often interrupted by lines of growth.

"Except for the imperforate beak, this might be taken for an Oolitic

*Terebratula.* It is so like the general shape of the species above quoted, that I can hardly think it distinct; however, the narrow distinct sinus that runs down the larger valve appears constantly to distinguish it from *T. camelina.* M. de Verneuil, who has seen our specimens, pronounces the species distinct. *T. prunum*, of Dalman, from Gothland, is nearly allied, but still quite another species."

*Localities.*—Cape Riley, abundant. Cornwallis, Leopold, Griffith's and Seal Islands. This species is also most abundant on Beechey Island.

Our figures on Plate X. are of immature specimens broken out of a mass of young *Atrypa phoca*, from Beechey Island, brought home by Dr. A. Horner of the "Pandora" (1875). We have since seen and compared these with the large series in the Sutherland Collection, Captain Penny, etc., and are satisfied from their gradations, that they are all referable to the same species. Mr. Salter's and Prof. Haughton's figures are of adult and aged specimens. We have slabs from Beechey Island entirely made up of specimens of this Brachiopod of all ages.

EXPLANATION OF PLATE X.

Fig. 1. *Strephodes* (*Lonsdalia ?*) *Austini*, Salter, U. Silurian or Devonian ? Beechey Island, Lat. 74° 40′ N., Long. 92° W.
,, 2. ——— ——— U. Silurian or Devonian ? Port Dundas, Lancaster Sound.
,, 3. *Favosites polymorpha*, Goldf. U. Silurian, Beechey Island.
,, 4. ——— *Gothlandica*, Linn. sp. U. Silurian, Beechey Island.
,, 5. *Cyathophyllum Pickthornii*, Salter. U. Silurian, Beechey Island.
,, 6. ——— ——— Salter. U. Silurian, Port Dundas.
,, 7. *Alveolites arctica*, H. Woodw. U. Silurian, Beechey Island.
,, 8. *Atrypa phoca*, Salter sp. (young state). U. Silurian, Beechey Island. *a.* front view, *b.* dorsal view, *c.* side view.

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## II.—Cataclysmic Theories of Geological Climate.[1]

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

of the Geological Survey of Scotland.

THE most important geological problem, and the one of all others which at present excites the greatest attention, is the cause of those extraordinary changes of climate which have taken place during past ages. How are we to account for the cold and Arctic condition of things which prevailed in temperate regions during what is called the Glacial Epoch, or for the warm and temperate climate enjoyed by the Arctic regions, probably up to the Pole, during part of the Miocene and other periods? Theories of the cause of those changes, of the most diverse and opposite character, have been keenly advocated, and one important result of the discussions which have recently taken place is the narrowing of the field of inquiry and the bringing of the question within proper limits.

At one time Lyell's theory of the relative distribution of land and water was generally regarded by geologists as sufficient. It is, however, now generally admitted to be wholly insufficient to explain the now-known facts, and the conviction is becoming almost

[1] Read before the Geological Society of London, May 8th, 1878.

universal that we must refer the climatic changes in question to some cosmical cause.

The theory of a change in the obliquity of the ecliptic has been appealed to. This theory for a time met with a favourable reception, but, as might have been expected, it was soon abandoned. The researches of Mr. Stockwell of America, and of Mr. George Darwin and others in this country, have put it beyond doubt that no probable amount of geographical revolution could ever have altered the obliquity to any sensible extent beyond its present narrow limits. It has been demonstrated for example, by Mr. George Darwin, that supposing the whole equatorial regions up to lat. 45° N. and S. were sea, and the water to the depth of 2000 feet were placed on the Polar regions in the form of ice—and this is the most favourable redistribution of weight possible for producing a change of obliquity—it would not shift the Arctic circle by so much as an inch!

Variations in the obliquity of the ecliptic having been given up as hopeless, geologists and physicists are now inquiring whether the true cause may not be found in a change in the position of the earth's axis of rotation. Fortunately this question has been taken up by several able mathematicians, among whom are Sir William Thomson,[1] Professor Haughton,[2] Mr. George Darwin,[3] the Rev. J. F. Twisden,[4] and others; and the result arrived at ought to convince every geologist how hopeless it is to expect aid in this direction.

Mr. George Darwin has demonstrated that in order to displace the pole merely 1° 46′ from its present position, $\frac{1}{20}$ of the entire surface of the globe would require to be elevated to a height of 10,000 feet, with a corresponding subsidence in another quadrant. There probably never was an upheaval of such magnitude in the history of our earth. And to produce a deflection of 3° 17′ (a deflection which would hardly sensibly affect climate) no less than $\frac{1}{10}$ of the entire surface would require to be elevated to that height. A continent ten times the size of Europe elevated two miles would do little more than bring London to the latitude of Edinburgh, or Edinburgh to the latitude of London. He must be a sanguine geologist indeed who can expect to account for the glaciation of this country, or for the former absence of ice around the poles, by this means. We know perfectly well that since the Glacial Epoch there have been no changes in the physical geography of the earth, sufficient to deflect the pole half-a-dozen miles, far less half-a-dozen degrees. It does not help the matter much to assume a distortion of the whole solid mass of the globe. This, it is true, would give a few degrees additional deflection of the Pole; but that such a distortion actually took place is more opposed to geology and physics than even the elevation of a continent ten times the size of Europe to a height of two miles.

Mr. Twisden, in his valuable memoir referred to, has shown even more convincingly how impossible it is to account for the great

[1] British Association Report, 1876 (part 2), p. 11.
[2] Proceedings of Royal Society, vol. xxvi. p. 51.
[3] Transactions of Royal Society, vol. 167 (part 1).
[4] Quart. Journ. Geol. Soc. February, 1878.

changes of geological climate on the hypothesis of a change in the axis of rotation. This conclusion has been further borne out by another mathematician, the Rev. E. Hill, in an article in the June Number of the GEOLOGICAL MAGAZINE. And Professor Haughton, in a paper read before the Royal Society, April 4th, and published in *Nature,* July 4th, entitled, "A Geological Proof that the Changes of Climate in Past Times were not due to Changes in the Position of the Pole," has proved from geological evidence that the Pole has never shifted its position to any great extent. "If we examine," he says, "the localities of the fossil remains of the Arctic regions, and consider carefully their relations to the position of the present North Pole, we find that we can demonstrate that the Pole has not sensibly changed its place during geological periods, and that the hypothesis of a shifting pole (even if permitted by mechanical considerations) is inadmissible to account for changes in geological climates."

There is no geological evidence to show that, at least since Silurian times, the Atlantic and Pacific were ever in their broad features otherwise than they are now—two immense oceans separated by the Eastern and Western continents—and there is not the shadow of a reason to conclude that the poles have ever shifted much from their present position. On this point I cannot do better than quote the opinion recently expressed by Sir William Thomson:

"As to changes of the earth's axis, I need not repeat the statement of dynamical principles which I gave with experimental illustrations to the Society three years ago; but may remind you of the chief result, which is that, for steady rotation, the axis round which the earth revolves must be a 'principal axis of inertia,' that is to say, such an axis that the centrifugal forces called into play by the rotation balance one another. The vast transpositions of matter at the earth's surface, or else distortions of the whole solid mass, which must have taken place to alter the axis sufficiently to produce sensible changes of the climate in any region, must be considered and shown to be possible or probable before any hypothesis accounting for changes of climate by alterations of the axis can be admitted. This question has been exhaustively dealt with by Mr. George Darwin in a paper recently communicated to the Royal Society of London, and the requisitions of dynamical mathematics for an alteration of even as much as two or three degrees in the earth's axis in what may be practically called geological time shown to be on purely geological grounds exceedingly improbable. But even suppose such a change as would bring ten or twenty degrees of more indulgent sky to the American Arctic Archipelago; it would bring Nova Zembla and Siberia by so much nearer to the pole: and it seems that there is probably as much need of accounting for a warm climate on one side as on the other side of the pole.[1] There is in fact no evidence in geological climate throughout those parts of the world which geological investigation has reached, to give any indication of the poles having been anywhere but where they are at any period of geological time."[2]

[1] This has been proved to be the case by Prof. Haughton, *Nature,* July 4, 1878.
[2] Trans. of Geol. Soc. of Glasgow, Feb. 22, 1877.

In the memoir from which the preceding paragraph is quoted, Sir William maintains that an increase in the amount of heat conveyed by ocean currents to the Arctic regions, combined with the effect of Clouds, Wind, and Aqueous Vapour, is perfectly sufficient to account for the warm and temperate condition of climate which is known to have prevailed in those regions during the Miocene and other periods.

Now this is the very point for which I have been contending for upwards of a dozen years. The only essential difference between Sir William's views and mine is simply this: he accounts for an increase in the flow of warm water to the Arctic regions by a submergence of the circumpolar land, whereas I attribute it to certain agencies brought into operation by an increase in the excentricity of the earth's orbit. Such geological evidence as we possess of warm episodes in the polar regions does not point to such high temperatures being specially due to submergence of the polar land. For taking the Miocene epoch as an example, all the way from Ireland and the Western Isles, by the Faroes, Iceland, Franz-Joseph Land, to North Greenland, the Miocene vegetation and the denuded fragmentary state of the strata point to a much wider distribution of polar land than that which now obtains in those regions. What has chiefly tended to retard the acceptance of the theory of secular changes of climate discussed in my work entitled "Climate and Time," is the fact that physicists have not fully realized to what an immense extent the climatic condition of our globe is dependent upon the distribution of heat by means of ocean currents. Were it not for the enormous amount of heat transferred from equatorial to temperate and polar regions by means of ocean currents, the globe would scarcely be habitable by the present orders of sentient beings. When this fact becomes fully recognized, all difficulties felt in accounting for geological climate will soon disappear. The climatic influence of ocean currents has not been sufficiently considered, owing doubtless to the fact that before I attempted to compute the absolute amount of heat conveyed by the Gulf Stream, so as to compare it with the amount directly received by the Atlantic from the sun, no one had ever imagined that that ocean in temperate and Arctic regions was dependent to such an extent on heat brought from the Equator.[1] And this being so, it was impossible for any one fully to realize to what an extent climate must necessarily be affected by an increase or a decrease of that stream.

Sir William Thomson speaks of his theory being that of Lyell; but beyond the mere assumption of the submergence of the circumpolar land the two theories have little in common. Indeed, no one who believes (as Sir William does) that the former warm climatic condition of the polar area was mainly due to a transference of heat from equatorial to Arctic regions by means of ocean currents can logically adopt Lyell's theory. According to that eminent geologist, the temperature of the Arctic regions was raised by the removal of the continents from polar and temperate regions to a position along

[1] Capt. Maury, of the U.S. Navy, was the first to call attention to the influence of the Gulf Stream on climate. Physical Geography of the Sea, 8th edition, 1860, p. 23.—Edit. Geol. Mag.

the equator. But if the equatorial regions were occupied by land instead of water, the possibility of conveying heat to temperate and arctic regions by means of ocean currents was completely cut off. In fact, one of the most effectual ways of lowering the mean temperature of the globe would be to group the continents along the equator.

The surface of the ground at the equator becomes intensely heated by the solar rays, and this heat is radiated into space much more rapidly than it would from a surface of water warmed under the same conditions. Again, the air in contact with the hot ground becomes more speedily heated than it would if it were in contact with water, and consequently the ascending current of air over the equatorial lands carries off a greater amount of heat than it could have done from a water-surface. Now, were the heat thus carried off to be transferred by means of the upper currents to high latitudes, and there employed in heating the earth, then it might to a considerable degree compensate for the absence of warm ocean currents. In such a case land at the equator might be nearly as well adapted as water for raising the temperature of the whole earth. We know very well, however, that the heat carried up by the ascending current at the equator performs little work of this kind, but on the contrary is almost wholly dissipated into the cold stellar space above. Thus instead of warming the globe, this ascending current is in reality a most effectual means of getting rid of the heat received from the sun, and thereby reducing the temperature. Since then the earth loses as well as gains the greater part of her heat in equatorial regions; it is there that the substance best adapted for preventing the dissipation of that heat must be distributed in order to raise the general temperature. Now, of all substances in nature water seems to possess this quality in the highest degree; and being a fluid it is adapted by means of currents to carry the heat which it receives to every region of the globe.

It has been urged as an objection to any ocean-current theory that while it provides the requisite amount of heat, it fails to remove the three or four months' darkness of an Arctic winter, which must have proved fatal to plants of the Miocene period. This objection seems, however, to have no foundation in fact. Sir Joseph Hooker stated to the Royal Society at the close of the reading of Mr. George Darwin's paper that palms and other plants brought from the tropics survived the winter in St. Petersburg without damage, though matted down in absolute darkness for more than six months. And he was of opinion that the want of sunlight during the Arctic winter would not be very prejudicial to the plants.

But a cause must be found as well for the cold of the Glacial Epoch as for the warm climate of the Arctic regions that obtained in Miocene times. According to Lyell the continents would require to be moved to high temperate and polar regions to bring about a glacial condition of things in Britain. But this is an assumption which the present state of geological science will hardly admit. It is perfectly certain that there have been no such vast revolutions in physical geography in post-Tertiary times.

According to others, elevation of the land in the regions glaciated is assigned as the cause of that glaciation, and if the ice had been merely local, such an explanation might have sufficed. But we know the whole Northern Hemisphere down to tolerably low latitudes has been subjected in post-Tertiary times to the rigour of an Arctic climate; so that according to this theory we must assume an upheaval of the entire hemisphere—an assumption too monstrous to be admitted and as useless as absurd.

*Tendency in Geology to Cataclysmic Theories.*—There has always been in Geology a tendency to cataclysmic theories of causation; a proneness to attribute the grand changes experienced by the earth's crust to extraordinary causes. Geologists have only slowly become convinced that those changes were the effects of the ordinary agencies in daily operation around us. For example, hills were formerly supposed to be due to sudden eruptions and upheavals; valleys to subsidences, and deep river gorges to violent dislocations of the earth. All this is now changed, and geologists in general have become convinced that the main features of the earth's surface owe their existence to the silent, gentle, and continuous working of such influences as rain and rivers, heat and cold, frost and snow.

It is not difficult to understand why a belief in cataclysms should so long have prevailed, and geologists should have been so prone to assume the existence of extraordinary causes acting with great force. Geological phenomena come directly under the eye in all their magnitude, and consequently produce a powerful impression on the mind. The quiet and gentle operations of nature's ordinary agencies appear utterly inadequate to produce results so stupendous; and one naturally refers effects so striking to extraordinary causes. Beholding in a moment the effect, we forget that the cause has been in operation for countless ages.

We look for example at a gorge, perhaps a thousand feet in depth, with a small streamlet running along its bottom. Our first impression is that this enormous chasm has been formed by some earthquake or other convulsion of nature rending the rocks asunder. And it is only when we examine the chasm more minutely, and find that it has been actually excavated out of the solid rock, that we begin to see that the work has been done by running water. At first, however, we do not imagine that such a chasm can have been made by the streamlet in its present puny form. We conclude that in former ages a great river ran down the channel. We fail to give the element of time due influence in our speculations. We overlook the fact that the streamlet has been deepening its bed for perhaps millions of years. Why, London itself might have been built by one man had he been at work during all the time that the streamlet was cutting out its gorge! When such considerations cross the mind, every difficulty vanishes, and we feel satisfied that all the work has been performed by the streamlet.

The very same may be said in regard to the origin of hills, valleys, and other features of the earth's surface. Yet how difficult it is still to convince some geologists that our mountains have been formed, as a rule, not by eruptions and upheavals, but by the slow process of subaerial denudation.

Cataclysmic explanations of phenomena have to a large extent disappeared from the field of physical geology. But there is one department in which they still monopolize the field; viz. in that which treats of great climatic changes in former ages. Just as in physical geology great and imposing effects have been attributed to extraordinary causes, so in questions of geological climate vast vicissitudes have been referred to equally vast and unusual agencies.

We know that at a period comparatively recent almost the entire Northern hemisphere down to tolerably low latitudes was buried under snow and ice, the climate being perhaps as rigorous as that of Greenland at the present day. And we know further that at other periods, Greenland and the Arctic regions were not only to a large extent at least free from ice, but also enjoyed a climate as warm and genial as that of England. To attribute results so striking and stupendous to such commonplace agencies as ocean currents, winds, clouds, and aqueous vapour is at present considered to be little else than absurd. Extraordinary and imposing causes proportionate to the effects are therefore sought.

To account for the Glacial Epoch, for example, the land was at one time supposed to have stood much higher than at present. It was soon discovered, however, that the glaciation was much too general to be explained by such means. Others believed that it might be accounted for by assuming a displacement of the continents, but this hypothesis had likewise to be abandoned when it became known that no alteration in the position of our continents and ocean basins has taken place since the Glacial Epoch.

Others again imagined that some great change had probably taken place in the obliquity of the ecliptic so as to bring the Arctic circle down to beyond the latitude of England. And in order to bring this about what enormous upheavals were supposed to have occurred! It was soon, however, shown that no possible rearrangement of matter on our globe could materially affect the obliquity; and besides this, it was further pointed out that even supposing the Arctic circle was by such means to be shifted down to our latitude, yet it would not bring an Arctic climate along with it but the reverse. This hypothesis being in its turn abandoned, it was next assumed that the earth's axis of rotation must have been moved so as to carry our island up to the Arctic regions. But to shift the axis of rotation even so much as 3°, upheavals and subsidences of a magnitude hitherto unheard of in geological speculations had to be assumed. A change of 3°, however, being totally inadequate to account for the great changes of climate in question, earthquakes of sufficient power to break up the solid framework of the globe had to be called into operation, so as to cause a rearrangement of matter sufficient to produce a displacement of the pole to the extent required. The amount of distortion necessitated by this theory is so enormous that most of its advocates have recently abandoned it as hopeless.

But is there really after all any necessity for invoking the aid of agencies so extraordinary and gigantic? To carve a country, say like Scotland, out of hard Silurian rock into hill and dale and mountain ridges, thousands of feet in height, is certainly a more stupendous undertaking than simply to cover the same area with a sheet of ice. And if commonplace agencies like rain and rivers, frost and snow, can do the former, why may not such agencies as ocean currents, winds, clouds, and aqueous vapour, be sufficient for the latter?

That geological climate should depend on the causes to which we refer cannot appear more improbable to the geologists of the present day than the inference that hills and valleys were formed by atmospheric agencies did to the geologists of the last generation. And there is little doubt that by the next generation the one conclusion will be as freely admitted as the other.

When a physicist so eminent as Sir William Thomson expresses his decided opinion that the agencies in question are all that are necessary to remove the ice from the Arctic regions, and confer on them a mild and temperate climate, it is to be hoped that the day is not far distant when the climate controversy will be concluded. When the fact comes to be generally admitted by physicists that a great *increase* in the temperature and volume of the ocean currents flowing polewards is sufficient to prevent the accumulation of ice in the Arctic regions, it will then be allowed that we only require a great *decrease* in the volume and temperature of the currents in order to account for the former accumulations of ice on the temperate regions, or, in other words, to explain the occurrence of the Glacial Epoch. And when this position is reached, it will be seen that the whole depends upon a very simple cause, requiring neither the submergence nor the elevation of continents, nor any other great change in the physical geography of the globe.

When the excentricity of the earth's orbit is at a high value and the Northern winter solstice is in perihelion, agencies are brought into operation which make the S.E. trade winds stronger than the N.E., and compel them to blow over upon the Northern hemisphere as far probably as the Tropic of Cancer. The result is that all the great equatorial currents of the ocean are impelled into the Northern hemisphere, which thus, in consequence of the immense accumulation of warm water, has its temperature raised, and snow and ice to a great extent must then disappear from the Arctic regions. When the precession of the equinoxes brings round the winter solstice to aphelion, the condition of things on the two hemispheres is reversed, and the N.E. trades then blow over upon the southern hemisphere, carrying the great equatorial currents along with them. The warm water being thus wholly withdrawn from the Northern hemisphere, its temperature sinks enormously, and snow and ice begin to accumulate in temperate regions. The amount of precipitation in the form of snow in temperate regions is at the same time enormously increased by the excess of the evaporation in low latitudes resulting from the nearness of the sun in perihelion during summer.

The final result to which we are, therefore, led, is, that those warm and cold periods, which have alternately prevailed during past ages, are simply the great secular summers and winters of our globe, depending as truly as the annual ones do upon planetary motions, and like them also fulfilling some important ends in the economy of Nature.

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## III.—Land Plants in the Irish Silurians.

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

The land-plants lately discovered both in the American and Continental Silurians seem to be attracting attention, while those found in Ireland nearly a quarter of a century ago appear to be quite forgotten. This is probably due to the unsatisfactory condition in which the classification of the Irish Silurians are left at the present time; perhaps therefore it is allowable for me to give a short description of these rocks.

There are considerable areas in different parts of Ireland in which the rocks are apparently of about similar age; the larger of these being: 1st, a tract in the Dingle Promontory, county Kerry (*Dingle beds*); 2nd, a very extensive area in South-west Cork (*Glengariff grits*); 3rd, a tract South-west of Clew Bay, county Mayo (*Louisburgh group*); 4th, an area east and north-east of Clew Bay (*Croaghmoyle conglomerates*); 5th, a long narrow tract in the Curlew Mountains, counties of Sligo and Roscommon (*Lough Gara beds*); 6th, an extensive area in the counties of Fermanagh and Tyrone (*Fintona and Slievemore group*); but besides these there are some small patches. In these rocks good fossils are not recorded; excepting the Glengariff grits, which contain tracks probably Crustacean at the Light House, Valencia Island; fucoids (?), on the shore of Valencia River; plants (?) on the south side of Beginish and on the sea-shore near Puffin Island; on the west side of Coomasaharn Lake, south-east of Kells, plant-stems, some of them an inch and a half in diameter, and irregularly ribbed in a longitudinal direction; and in the Glengariff grits, south and south-west of Killarney, imperfect plants were observed in many places, the most perfect occurring in the Owenreagh valley north of Windy Gap.

In the later editions of Griffith's map the Dingle, Glengariff, and Louisburgh rocks were classed as Silurians, while the others *provisionally* were placed as Old Red Sandstone, because, as stated by that eminent geologist, he never had time to properly examine them. During the progress of H.M. Geological Survey it was found that the Glengariff grits were conformable with the overlying Carboniferous rocks in the county of Cork; while in the year 1854, *low down* near the bottom of the Glengariff grits, Du Noyer found plants, and in the following year I also found them; these plants were supposed by the late Mr. J. W. Salter to be of Carboniferous types. In 1856, Du Noyer, in the Dingle Promontory, found that similar rocks to the Glengariff grits (as had been previously known to Griffith) lay conformably on rocks containing typical Silurian fossils, while they were overlaid unconformably by about 5000 feet in thickness of Old Red Sandstone (Lower Carboniferous Sandstone). In the autumn of the same year these rocks were visited by Griffith, Murchison, Salter, and Jukes. The first two were inclined to place the Dingle and Glengariff rocks among the Silurians, while the other two objected on account of the fossils,—eventually it was arranged that they were to be joined provisionally to the Old Red Sandstone under the names of Dingle beds and Glengariff grits, until the somewhat similar rocks in Connaught and Ulster were examined. Afterwards, Jukes, although he did not separate the Glengariff grits from the Old Red Sandstone, gave the Dingle beds a distinct grouping; but Du Noyer, and all the other officers who were engaged in the examination of the country, considered that the Dingle beds and Glengariff grits were of one age. During Jukes's lifetime, these rocks were being gradually worked out; but after his death seemingly they have been forgotten.

The Louisburgh beds, although no fossils have been found in them, except some Annelid burrows and obscure markings, are in part similar to the fossiliferous Salrock beds, and in part like the fossiliferous Mweelrea beds; they probably are the newest group of the Silurians in Mayo. The Croaghmoyle conglomerates seem to be capped unconformably by Carboniferous rocks; they are like the Toormakeedy conglomerates, associated with which Upper Llandovery fossils occur; also the limestones that occur in the Toormakeedy rocks seem to occur in places at the margin of Croaghmoyle conglomerates. In red beds associated with the Croaghmoyle conglomerates I detected obscure markings that possibly might be fucoids, but they were so very indistinct that no reliance could be placed on them.

The Lough Gara rocks were suspected by Griffith to be similarly placed to the rocks at Dingle; that is, to lie conformably on the Silurians, while they were capped unconformably by Old Red Sandstone (Lower Carboniferous Sandstone). When I visited them with Foote, that observer seemed inclined to class them with the Dingle beds, but unfortunately he did not live to complete his examination. In the Government Survey Memoirs, Ex. Sheet 76, page 7, Berdoc Wilkin says of these rocks near Ballyhaderreen, "They appear to be conformable with the Silurian beds, but are overlapped unconformably . . . . . by the Lower Carboniferous Sandstones"; this observer coming to the same conclusion as that suggested by Griffith and Foote. Foote suspected that fossil plants occurred in these rocks.

The Fintona and Slievemore rocks are very similar to those in the Curlew Mountains, and are capped unconformably by the Old Red Sandstone (Lower Carboniferous Sandstone). Portlock states that they seem to pass conformably into the underlying Cambro-Silurian rocks, which would make them of great age; but Griffith suggested that they were of the same age as the Dingle beds. The Dingle, the Mweelrea, the Toormakeedy, the Curlew Mountain, and the Fintona rocks have conditions in common: all are unconformable with the overlying Lower Carboniferous Sandstone (Old Red Sandstone); all have similarly associated basic felstones (Eurytes) and tuffs; and all, except the Fintona rocks, lie conformably on rocks containing typical Silurian fossils.

It may be mentioned that although attempts have been made to classify the Irish Silurians similarly to those of England, yet it is not a satisfactory classification, as the fossils of the English groups are mixed up together in the Irish ones; this is a subject which if fully entered into would take up too much space, but it may be mentioned that in the Kerry, Galway, and Mayo Silurians there is a thin zone, at about the same geological horizon, which carries Cambro-Silurian (Caradoc) fossils, while in the rocks below and above they are of Upper Llandovery and Wenlock types. In one portion of Galway there are at least 3000 feet in thickness of Upper Llandovery rocks below this zone. I would suggest that the American and Continental Silurians in which Land Plants occur are possibly equivalents of the Irish groups to which I now draw attention.

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NOTE.—Prof. Claypole has described a Lepidodendroid plant, *Glyptodendron Eatonense*, from the Upper Silurian (Clinton) rocks of Ohio, in the American Journal of Science for April, 1878, p. 302.—J. M.

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## IV.—On a Flint Implement from the Barnwell Gravel.

By A. F. Griffith, Esq.

A FEW weeks ago a flint implement was found in the gravel-pit at Barnwell, near Cambridge, by the workmen, from whom I bought it. It is a very fine specimen of the hache type, its greatest length being $6\frac{3}{4}$ ins., its greatest breadth $3\frac{5}{8}$ ins., and thickness $2\frac{1}{8}$. It corresponds closely with specimens in the Woodwardian Museum, from Thetford, in Suffolk, and from Amiens. It agrees almost exactly in size and outline with an implement of the "River-drift type," figured by Dr. John Evans in his beautiful work on the "Ancient Stone Implements of Great Britain"; from Biddenham, Bedford (fig. 414, p. 481); also with one from Redhill, Thetford (fig. 427, $\frac{1}{2}$ nat. size, p. 496, *op. cit.*).

The pit where it was found is in the well-known Barnwell river gravel, which contains a considerable number of bones of Mammalia, including those of *Bos*, *Equus*, *Cervus*, *Rhinoceros tichorhinus*, *Elephas primigenius* and *antiquus*, and *Hippopotamus*,[1] and has in places a thin band of shells, amongst which *Unio littoralis* and *Cyrena fluminalis* are common. This band, however, is not found in the present pit, though it occurred in the old pit about 350 yards distant, on the side of the Newmarket Road, which was in the same gravel, and is on the same level as the present one. The occurrence of a worked flint associated with these shells is, I believe, very unusual. At Menchecourt, in France, *Cyrena fluminalis* was found by Prof. Prestwich, in the implement-bearing gravel, while I only know of one instance having been recorded of a worked flint having been found associated with *Unio littoralis*; this was found in the brick-earth of Crayford, Kent, by Mr. Fisher, in 1872.[2]

The only other evidence of man's existence which has hitherto been obtained from this deposit is perhaps of a rather doubtful

[1] Quart. Journ. Geol. Soc., vol. xxii. p. 476.
[2] Geol. Mag. June, 1872.

character, consisting of a bone supposed to have been cut by man before its burial in the gravel. This was described by Prof. H. G. Seely, in his paper on the Fen Drifts.[1]

A few worked flints have been found round Cambridge, in gravel heaps by the road-side. Some specimens, now in the Woodwardian Museum, were found by Prof. Hughes, in gravel which came from the Observatory Hill. Mr. Fisher also has a small hache of much the same type as the Barnwell one, but much smaller, and more oval, being only $3\frac{1}{2}$ inches long; this he found in gravel which came from the Chesterton pits. Both this and the Observatory specimens are much more water-worn than that from Barnwell. The implements found at both these localities are of the regular "River-drift period" type, closely resembling several of the woodcuts in Dr. John Evans's "Ancient Stone Implements of Great Britain," *e.g.*, Implement from Santon Downham, fig. 436, p. 504; from Shrub Hill, Feltwell, fig. 448, p. 515; from Hoxne, Suffolk, fig. 449, p. 519; from Fordingbridge, Ashford, on the Wiltshire Avon, fig. 473, p. 555; also one from Wookey Hyæna-den, fig. 413, p. 473. I have also a well-marked chip, found in gravel in a little pit close to the railway on the south side, about one mile from Lord's Bridge Station, in the direction of Old North Road.

The section of the pit at the corner where my specimen was found is roughly as follows:—

| | | |
|---|---|---|
| i. | Surface soil ..... ..... ..... ..... ..... ..... ..... ..... | 3 feet. |
| ii. | Trail ..... ..... ..... ..... ..... ..... ..... ..... ..... | 1 to 2 feet. |
| iii. | Irregular gravel, with band of sand ..... ..... ..... | 3 to 2 feet. |
| iv. | Level-bedded gravel with marly bands ..... ..... | 9 feet. |

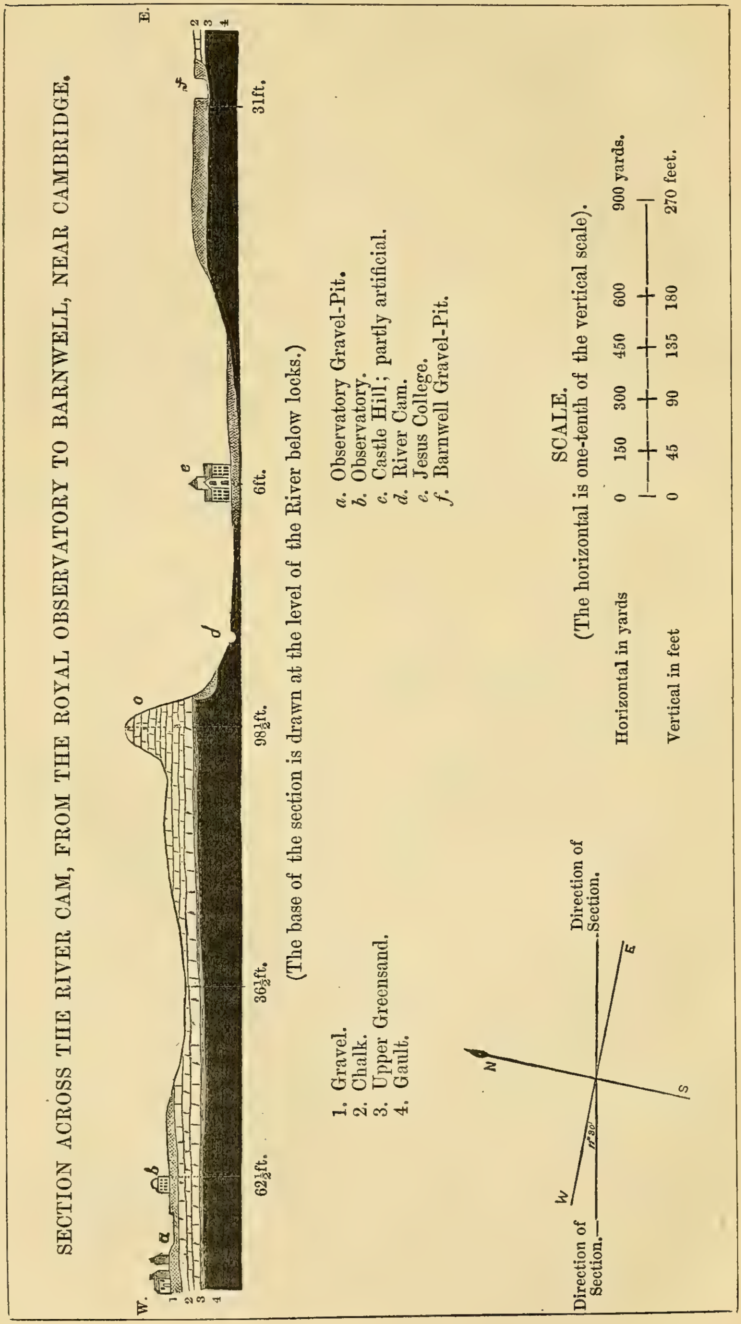
The implement was found near the top of the bed iv. The band with shells occurred near its base.

With regard to the authenticity of the specimen, I may say that when I got it, it had been partially cleaned, but all the corners were still full of the peculiar fine white gravel of the bed. I only gave one shilling for it, which goes to prove that the men found it on the spot, and did not buy it in the town to sell it at a high profit in the pit.

A remarkable character of the weapon is, that while on one side and at the blunt end it is of the yellowish colour so common in Palæolithic flints from gravel, its other side is much whitened, probably by the action of the infiltrated water which is highly charged with lime. At the suggestion of Prof. T. G. Bonney, I tried to find similar specimens among the rough unworked flints in the pit. In this I was only partially successful, as I could find none with the difference of colour on the two sides so marked; but this was, I believe, due to the fact that there are very few flints of any considerable size in the lower part of the deposit.

In the subjoined woodcut (p. 402) is given a section from the Observatory gravel-pit to that at Barnwell. The heights given are measured from the level of the river Cam below the Jesus College locks; the section cuts the river just above them; the direction of the section runs $11\frac{1}{2}°$ S. of West and N. of East. The base of the gravel

[1] Quart. Journ. Geol. Soc., vol. xxii. p. 477.


SECTION ACROSS THE RIVER CAM, FROM THE ROYAL OBSERVATORY TO BARNWELL, NEAR CAMBRIDGE.
W.
E.
a
b
c
d
e
f
1
2
3
4
62½ft.
36½ft.
98½ft.
6ft.
31ft.
(The base of the section is drawn at the level of the River below locks.)
1. Gravel.
2. Chalk.
3. Upper Greensand.
4. Gault.
a. Observatory Gravel-Pit.
b. Observatory.
c. Castle Hill; partly artificial.
d. River Cam.
e. Jesus College.
f. Barnwell Gravel-Pit.
N
S
E
W
Direction of Section.
Direction of Section.
SCALE.
(The horizontal is one-tenth of the vertical scale).
Horizontal in yards
0
150
300
450
600
900 yards.
Vertical in feet
0
45
90
135
180
270 feet.

on the Observatory Hill is about 56 feet above the present river level. The Castle Hill, which is partly natural, partly artificial, has at its base another bed, whose level I was unable to ascertain accurately; this probably belongs to the Chesterton gravel. Jesus College stands on gravel at a lower level still, while the base of the Barnwell bed is at a height of sixteen feet above the river level. Thus we have four distinct terraces, unless the Jesus College bed forms part of the Chesterton series, which is improbable.

I must express my thanks to Mr. O. Fisher, M.A., and Prof. Hughes, for the encouragement and help they have given me in the preparation of this brief notice. My thanks are also due to Mr. Haddon, of Christ's College, for his kindness in making drawings of the implements for me.[1]

CHRIST'S COLLEGE, *June*, 1878. A. F. GRIFFITH.

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## V.—WAYSIDE NOTES IN TRAVELS OVER EUROPE.—THE GREAT NORTHERN DRIFT.

By ROBERT DAMON, F.G.S.

THE overland route to Russia viâ Konigsberg or Warsaw—now accomplished with comparative ease—reveals some instructive facts connected with one of the most recent yet extreme of climatal changes which has contributed to mould and fashion so large a portion of the surface geology of Northern Europe. I refer to the "Great Ice Age," or "Glacial Period," when a frozen sea probably covered the extensive plains now known as Russian Poland.

Soon after leaving the German frontier, granitic débris and small stones everywhere appear on the surface. These granitic erratic boulders, for such they really are, increase in number and dimensions as the journey is pursued, so that in a few hours they have so augmented that a considerable distance might be traversed by stepping from one of these stones to another. Now and then there are some one or more of exceptionally large proportions, but taken as a whole, the increase in size is extremely uniform, and before the environs of St. Petersburg or Moscow is reached, many of them attain colossal dimensions. Having in my recollection the block of granite in the Admiralty Square in St. Petersburg, on which stands the equestrian statue of the Czar Peter, many of the boulders referred to are hundreds of tons each in weight. In some instances the railway has paid respect to their dimensions and avoided them, for no ordinary mechanical power could effect their removal. As may be expected, their size increases as their source is approached, though on sea-beaches the larger pebbles are carried the furthest because they are said to offer a larger surface for the moving force to act upon.

It requires but little penetration to discern that the direction of the transporting power by which this vast mass of erratics has been sown broadcast over the central plain of Europe, has acted from N. or N. E. to S. and S. W. Several specimens of granite gneiss, etc., I

[1] These are not reproduced here, it being believed sufficient to refer the reader to Dr. John Evans's work.—EDIT. GEOL. MAG.

was able to identify as having been derived from the granitic region of Finland, nearly 1000 miles distant, while others have been traced to the rocks which surround the shores of Lake Ladoga, immediately north of St. Petersburg.

The amount of material transported is not to be judged merely from what appears on the surface. When a space has been opened and the soil removed, Boulders are exposed piled one upon the other in heaps to an enormous depth, recalling to one's mind the accumulated masses of rocks on the shore of a lofty line of coast. These quarries in the Boulder formation being, humanly speaking, inexhaustible, will ever be a source of valuable building material to a district where no other stone besides can be obtained; and when it is further considered that this represents an area of probably 1000 miles in one direction, we realize in part the potency of this most ancient but, comparatively speaking, recently recognized of geological agencies *Ice*—either as Coast-ice, Pack-ice, Glaciers, or Icebergs.

In the district around Konigsberg other boulders abound from a different region, viz. the Silurian rocks of Sweden. These are so numerous that in the University Museum of that city a really fine collection of Silurian fossils has been formed, derived exclusively from boulders transported over the Baltic. As the cold of the Glacial Period gave way to a more genial climate, the waters formed for themselves outlets to the Baltic in the rivers Vistula, Niemen, Dwina, etc., thus creating so many highways extending far into the interior of the vast corn-growing plains of Russian Poland. Here during the winter and spring barges of enormous dimensions are constructed on the ice ready to float down the stream at the return of summer, laden with wheat, to stock the granaries of their respective ports of Dantzic, Konigsberg, etc., from whence Europe draws much of her supplies of grain.

This enormous tract consists of almost unbroken alluvial plains, as boundless as the ocean, without a tunnel, a cutting or a bridge being visible through an entire day's journey. The railroad is so straight and the scenery so monotonous, that the traveller can hardly realize his onward progress; the track seems ever to converge towards the same vanishing points on the horizon both in front and behind. Having taken this route many years since, and before the completion of the railway into Russia, I observed how the country on each side of the line of rails has been cleared, and the granite blocks utilised for building purposes, road-metal, etc.

In the Northern Cemeteries the boulders are also frequently used as tomb-stones; those being selected that have a wide base; but no tool is applied to them save for the inscription, which is as simple as the monolith itself. For example:

"Admiral Schonbein.
1824 — 1875."

The journey derives additional interest from historic associations, as it was at Kowno, the frontier station, that the French army, consisting of 453,000 men, on the 24th and 25th June, 1812, crossed the Niemen; and at Wilna, the station following, where, on December 13th, six months after, Napoleon united his retreating force, reduced to less than 25,000 men,—the Russians, desertions and the cold disposing of the remainder.

After describing the terrible passage of the Beresina, Labaume, one of Napoleon's staff, writes:—"Arrived at the opposite bank, like ghosts returned from the infernal regions, we fearfully looked behind us, and beheld with horror the savage countries where we had suffered so much."

## NOTICES OF MEMOIRS.

### Sketch of the Geology and Palæontology of the Pliocene Beds of the Antwerp District. By E. Vanden Broeck. Fasc. II. (Brussels, 1878.)[1]

THE first fascicule of this work was published in 1876 and noticed in the Geological Magazine for July, 1877. With the fascicule now issued, it forms a stratigraphical introduction to MM. Vanden Broeck and Miller's Foraminifera of the Belgian Pliocene, being Part I. of that work.

The first fascicule dealt with the Lower Sands of Antwerp, the second takes up the Middle and Upper Sands of the same district, concluding with a general *résumé* of the entire work, a table of stratigraphical equivalence, here reproduced, a list of works on the subject, further data and corrections, and a topographical chapter explanatory of the map (not geological) of the area under discussion.

The Middle Sands have been designated as follows:

| | |
|---|---|
| Scaldesian (in part) ... ... ... ... | Dumont, 1849. |
| Grey or Middle Crag ... ... ... ... | Lyell, 1852. |
| Grey Sands (in part) ... ... ... ... | Nyst, 1861. |
| *Isocardia cor* Sands and Bryozoan Rock ... ... | Cogels, 1874. |

They consist generally of fine sand, more or less clayey, and very rarely coarse or pebbly: the glauconite grains in them are less abundant and smaller than in the Lower Sands. They have been divided into Grey and Yellow Sands, and correlated with the White and Red Crags of England respectively on the strength of this difference in colour. The fallacy of applying such a test is abundantly shown by the author, whose remarks on this important subject may be summed up as follows:—

Percolating water charged with carbonic acid and oxygen acts on both glauconite and carbonate of lime. Where percolation is rapid, it oxidises the glauconite; where slow, it dissolves away the fossils. Thus the surface of any glauconitic or shelly deposit whether exposed directly or covered by permeable beds, is deprived of fossils and oxidised to a greater or less extent, the capricious

[1] Les Foraminifères des Couches Pliocènes de la Belgique. Par E. Vanden Broeck et H. Miller. 1re partie: Esquisse Géologique et Paléontologique des Dépôts Pliocènes des Environs d'Anvers. Par Ernest Vanden Broeck. Extrait des Annales de la Société Malacologique de Belgique, tome ix. pp. 83–379 [both fascicules], pl. iv.

percolation of water giving rise to great irregularity of alteration, and producing the appearance, often strongly marked, of unconformity. To separate such deposits by their colour, therefore, is to mass all altered beds as of one age, all unaltered as of another, leading of course to hopeless confusion in lists of fossils based on this division, and this confusion has been increased by the inclusion of specimens from post-Tertiary deposits of similar lithological character. All lists hitherto published are therefore to a large extent worthless, with the exception of those recently compiled by M. Cogels.

The Middle Sands are rather Diestian than Scaldesian in their faunal affinities, and slightly anterior to the Coralline Crag, to which they are closely allied. By the northward and westward movement of the area of deposition, due to the elevation of Belgium and simultaneous depression of Holland and East Anglia, the Coralline Crag was still in process of deposition when the Belgian area emerged.

The Middle Sands have two facies, one of comparatively shallow water, distinguished by the predominance of *Isocardia cor*, the other of deeper water, notable for its profusion of Bryozoa. Enormous quantities of Cetacean bones, often as entire skeletons and connected vertebral columns, occur throughout the series, but the Ziphioids and Delphinidæ of the Lower Sands are here replaced by Mysticeti and Phocidæ. The fish are mostly Selachians, some of them of enormous bulk.[1]

Like the Coralline Crag, the Middle Sands have suffered great denudation previous to the deposition of the Upper Sands (=Red Crag).

Remarks on the horizon of certain local deposits and of *Terebratula grandis* (a Middle Sands species referred by M. Cogels, from deficient evidence, to the Lower Sands) are followed by a sketch of the geography of the Middle Sand period. The Belgian basin extended from Cotentin to Denmark and Iceland: the Mediterranean had nearly its present outline, whilst in Austria and South Russia occur isolated marine deposits of this age.

Passing to the Upper Sands we find a number of synonyms of which but one need be named, *Sables à Trophon antiquum*, given by M. Cogels in 1874.

The Upper Sands are of littoral origin, coarse and pebbly, rarely more than 14 feet thick, grey where protected by overlying impermeable beds from percolating water, but mostly oxidised. Their derived fossils being clearly distinguishable from contemporaneous species, these Antwerp beds may help to settle the vexed question of "derivation" in the English Red Crag, as many species from the latter, supposed to be derived, are found in the Upper Sands.

As with the previous series, the Upper Sands are slightly anterior to the Red Crag, except perhaps the Crag of Walton-on-the-Naze, which has an earlier facies than the rest of the Red Crag, and may be synchronous with the Upper Sands. The base of both contains

[1] *Carcharodon megalodon* was 70 feet long, and its jaws were 14 feet in circumference.

SYNOPTICAL AND CHRONOLOGICAL TABLE OF THE PLIOCENE AND QUATERNARY BEDS OF THE ANTWERP BASIN.

| Geological Periods and Phases. | | Dunes & Raised Beaches. | Littoral and Beach Deposits. | Coast and Shallow Water Deposits. | Deep-Water Deposits distant from the Coast. |
|---|---|---|---|---|---|
| Quaternary. | Campinien. | Blown Sands. Upper Campinien. | Stratified Clays and Sands of the Lower Campinien of Kiel, etc. | | |
| | Diluvium. | | Beds with casts and fragments of Pliocene shells and bones of the Mammoth and Rhinoceros. Drift with Flints. | | |
| | | Total emergence of the Pliocene Basin of Antwerp. | | | |
| Pliocene. | Upper Sands of Antwerp. | Last phase of the Pliocene period represented by deposits not known in the Antwerp basin. | | | |
| | | | Shell-beds of Ranst and of the district to the East. | | |
| | | | Sands of Calloo with *Trophon antiquum*. | Argillaceous sands of Wyneghem with *Trophon antiquum*. | |
| | | | Bed with débris and casts of shells; first deposit of sands with *Trophon antiquum*. | | |
| | | Emergence succeeding the denudation of the Middle Sands of Antwerp. | | | |
| | Middle Sands of Antwerp. | | Littoral zone of the Port of Borsbeek; Bryozoan rock. | Sands of Deurne, etc., with *Isocardia cor*. | Sands of Wyneghem, etc., with Bryozoa. |
| | | Partial emergence of the Lower Sands of Antwerp. | | | |
| | Lower Sands of Antwerp. | Sands of Diest, or Diestien. Ferruginous sands. | Gravelly sands of Antwerp. | Sands with *Pectunculus pilosus*, of the environs of Antwerp. | |
| | | | Shell-banks of Bolderberg. | | Sands of Edeghem with *Panopæa Menardi*. |
| Miocene and Upper Oligocene. | | Emergence succeeding the denudation of the Oligocene deposits. | | | |
| Middle Oligocene. | Upper Rupélien. | 'Bolderian' sands of Bolderberg. | | Sandy clay of Bergh, etc., with *Nuculæ*. | Rupélien clay of Boom, etc. |

rolled and water-worn bones, many of them belonging to Cetaceans that could not have lived in the shallow seas of the period: these remains have been derived mostly, if not entirely, from the Middle Sands, where they abound in the unrolled and connected state.

Littoral beds occur East of Antwerp, indicating a later advance of the sea, possibly that produced by the depression which in Suffolk introduced the Chillesford series.

The geography of the Upper Sands period resembled in the main that of the preceding epoch, with the addition of a wide sheet of fresh or brackish water, which stretched from Austria to Tartary, and left as its isolated relics the Black, Caspian, and Aral seas.

[Copious lists of fossils, with statistical analyses of each, are adduced by the author in proof of his views, but for these the reader is referred to the original. The author desires the writer of this notice to add that he will be happy to present a copy of the work to any one interested in the subject. Applications may be made to W. Whitaker, Esq., B.A., F.G.S., Museum, Jermyn Street, S.W.]

W. H. D.

## REVIEWS.

I.—Iconographia Crinoideorum in Stratis Sueciæ Siluricis Fossilium Auctore N. P. Angelin. Opus Postumum Edendum Curavit Regia Academia Scientiarum Suecica. Folio, pp. 64. Cum Tabulis XXIX. (Holmiæ, Samson & Wallin; London, Trübner & Co., 1878.)

THERE is probably no better proof of disinterested regard which can be displayed for a deceased scientific man, than that his friends should undertake the very difficult and laborious task of preparing his posthumous works for publication. It was this feeling which led the disciples of the illustrious Cuvier to publish "Le Règne Animal," and Charles Murchison to edit "Falconer's Palæontological Memoirs." A noble example of this self-denying spirit is shown in the work before us by Prof. S. Lovén, and Dr. G. Lindström, the former a colleague of Angelin's, and the latter his recently appointed successor at Stockholm.

The unpublished MSS. of Angelin, handed over to the Academy by his family, were found to consist of various memoirs on the Trilobites, Cephalopoda, Graptolites, etc., but for the most part incomplete and unarranged.

In 1851 he published under the title of "Palæontologia Suecica" the first part of his Monograph of the Silurian Crustacea of Scandinavia; the second part entitled "Palæontologia Scandinavica" appeared in 1854. At his death in February, 1876, all the beautiful plates, 29 in number, published in the present volume, were found ready prepared and lithographed, part of the text was printed and part was found in MS. The Editors modestly lay claim only to the plan and systematic arrangement of the work (except the Cystidea), they having given Angelin's own generic and specific characters, merely reducing the same to order, and adding some needful notes on the synonymy. The name of Prof. S. Lovén, however, gives a very high importance to this Monograph, and it is sure to be largely in demand, so soon as its publication is made known, especially for the libraries of museums and scientific societies; to all those interested in Silurian fossils it becomes a necessary work of reference. No more beautiful figures of Crinoids have ever appeared than those so accurately portrayed in Angelin's plates, and the Latin text which accompanies them will render the work of the highest utility.

The author divides the Crinoidea into two great primary divisions, namely, I. Crinoidea proper;
and II. Cystidea.
The "Crinoidea proper" are again subdivided according to the number of their basal plates into four sections, viz.:—1. Trimera; 2. Tetramera; 3. Pentamera; and 4. Polymera.

The Cystidea are divided into three sections, namely, 1. Apora; 2. Gemellipora; 3. Pedicellata; Rhombifera. The author has abolished the termination in *ites* of genera like *Echinosphærites, Caryocystites, Sphæronites*; which are printed *Echinosphæra, Caryocystis, Sphæronis*; but the convenience of the termination in *ites* as a ready means of distinguishing generic names applied to fossil forms from those of existing representative genera (e.g.: *Pentacrinus* from *Pentacrinites*) is too generally recognized and has been too frequently used to be easily removed from our Nomenclator Palæontologicus.

The following is the classification adopted by the author for these two great groups.

I. CRINOIDEA PROPRIA.

Section I. Trimera.
- Fam. 1. Briarocrinidæ.
  - Genus, *Briarocrinus*, Ang. (2 sp.)
- Fam. 2. Patelliocrinidæ.
  - Genus, *Patelliocrinus*, Ang. (9 sp.)
- Fam. 3. Platycrinidæ.
  - Genus, *Marsupiocrinus*, Phill. (9 sp.)
  - ,, *Leptocrinus*, Ang. (1 sp.)
  - ,, *Cordylocrinus*, Ang. 1 (sp.)
- Fam. 4. Habrocrinidæ.
  - Genus, *Habrocrinus*, D'Orb. (14 sp.)
  - ,, *Pionocrinus*, Ang. (5 sp.)
- Fam. 5. Desmidocrinidæ.
  - Genus, *Desmidocrinus*, Ang. (4 sp.)
- Fam. 6. Actinocrinidæ.
  - Genus, *Actinocrinus*, Miller (9 sp.)
  - ,, *Periechocrinus*, Austin (9 sp.)
- Fam. 7. Barrandeocrinidæ.
  - Genus, *Barrandeocrinus*, Ang. (1 sp.)
- Fam. 8. Sagenocrinidæ.
  - Genus, *Sagenocrinus*, Austin (1 sp.)
- Fam. 9. Taxocrinidæ.
  - Genus, *Taxocrinus*, Phillips (10 sp.)
  - ,, *Forbesiocrinus*, DeKon. (4 sp.)
  - ,, *Gissocrinus*, Ang. (7 sp.)
  - ,, *Myelodactylus*, Hall (3 sp.)
- Fam. 10. Homalocrinidæ.
  - Genus, *Homalocrinus*, Ang. (1 sp.)
  - ,, *Lecanocrinus*, J. Hall (2 sp.)
  - Genus, *Clidochirus*, Ang. (2 sp.)
  - ,, *Calpiocrinus*, Ang. (4 sp.)
  - ,, *Anisocrinus*, Ang. (1 sp.)
- Fam. 11. Ichthyocrinidæ.
  - Genus, *Ichthyocrinus*, Conrad (3 sp.)
  - ,, *Pycnosaccus*, Ang. (3 sp.)

Section II. Tetramera.
- Fam. 1. Calyptocrinidæ (=*Eucalyptocrinidæ*.)
  - Genus, *Callocrinus*, D'Orb. (9 sp.)
  - ,, *Eucalyptocrinus*, Goldfuss (7 species).
  - ,, *Hypanthocrinus*, Phill. (3 sp.)
- Fam. 2. Corymbocrinidæ.
  - Genus, *Corymbocrinus*, Ang. (6 sp.)
  - ,, *Abacocrinus*, Ang. (4 sp.)
- Fam. 3. Melocrinidæ.
  - Genus, *Melocrinus*, Goldf. (5 sp.)
- Fam. 4. Cyrtidocrinidæ.
  - Genus, *Cyrtidocrinus*, Ang. (1 sp.)

Section III. Pentamera.
- Fam. 1. Pisocrinidæ.
  - Genus, *Pisocrinus*, De Koninck (4 species).
- Fam. 2. Stelidiocrinidæ.
  - Genus, *Stelidiocrinus*, Ang. (3 sp.)
  - ,, *Harmocrinus*, Ang. (1 sp.)
- Fam. 3. Chirocrinidæ.
  - Genus, *Chirocrinus*, Salter (1 sp.)

Fam. 4. CYATHOCRINIDÆ.
Genus, *Cyathocrinus*, Miller (14 sp.)
,, *Sicyocrinus*, Ang. (1 sp.)
,, *Euspirocrinus*, Ang. (1 sp.)
,, *Ophiocrinus*, Ang. (1 sp.)
,, *Botryocrinus*, Ang. (2 sp.)
Fam. 5. EUCRINIDÆ.
Genus, *Eucrinus*, Ang. (7 sp.)
Fam. 6. ENALLOCRINIDÆ.
Genus, *Enallocrinus*, D'Orb. (2 sp.)
Fam. 7. CROTALOCRINIDÆ.
Genus, *Crotalocrinus*, Austin (3 sp.)
Section IV. POLYMERA.
Fam. 1. POLYPELTIDÆ.
Genus, *Polypeltis*, Ang. (1 sp.)

II. CYSTIDEA.

Section I. APORA.
Genus, *Echinosphæra*, Wahlenberg. (1 species).
,, *Caryocystis*, v. Buch (7 sp.)
,, *Megacystis*, Hall (2 sp.)
Section II. GEMELLIPORA.
Genus, *Sphæronis*, Hisinger (8 sp.)
,, *Eucystis*, Ang. (1 sp.)
,, *Glyptosphæra*, Müller (1 sp.)
,, *Gomphocystis*, Hall (1 sp.)
Section III. PEDICELLATA; RHOMBIFERA
Genus, *Glyptocystis*, Billings (1 sp.)
,, *Lepadocrinus*, Hall (1 sp.)

The Cystidea have been specially edited by Prof. Lovén. All the Crinoidea enumerated and described in this work are from Swedish localities, but many of them are at once seen to be identical with British Silurian species, and it is for this reason more especially, that we have to thank Professor S. Lovén and Dr. G. Lindström for this very valuable contribution to palæontological science, Strange to relate, save for an exceptional paper here and there, this beautiful group of the Echinodermata have remained almost unnoticed in this country. Miller's Crinoidea (1821) and Austin's Crinoidea (1821-44), both rare works, being the only two separate memoirs published in this country on "Stone Lilies."

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II.—CATALOGUE OF THE HUTTON COLLECTION OF FOSSIL PLANTS, INCLUDING A SYNOPTICAL LIST OF THE CHIEF CARBONIFEROUS SPECIES NOT IN THE COLLECTION. By G. A. LEBOUR, F.G.S. Royal 8vo. pp. 132. (Newcastle-on-Tyne, Published for the Institute by Andrew Reid, Printing Court Buildings; London, Longmans and Co., 1878.)

THE work by Mr. G. A. Lebour containing the Illustrations of the Fossil Plants belonging to the large collection of the late Mr. W. Hutton, and not published in the "Fossil Flora," has been already noticed in this volume (p. 319). The present work by the same author may be considered as a companion to the former, and comprises a catalogue of the specimens in the Hutton Collection of Fossil Plants in the Newcastle Museum, which is of special value as illustrating the ancient flora of the Newcastle Coal-field.

Although greater attention has been paid in the Catalogue to such species as are represented in the Collection, or are figured in the "Fossil Flora" of Lindley and Hutton, the student will find most of the chief Carboniferous species of plants, either not found in the collection or known as British forms, therein enumerated, as well as lists of some Triassic or Jurassic plants, thus rendering the work of greater utility. The genera, with their principal diagnostic characters, are arranged chiefly according to the system adopted by Schimper in his Paléontologie Végétale, and the general catalogue is preceded by an introduction in which the early and present ideas prevalent as to the stratigraphical value of fossils, and to their distribution, are briefly stated. J. M.

# REPORTS AND PROCEEDINGS.

British Association for the Advancement of Science.—Dublin, August 15, 1878—Address delivered to the Geological Section. By John Evans, D.C.L., LL.D., F.R.S., F.G.S., etc., President of the Section.

IN opening the proceedings of this Section, I cannot but call attention to the fact that the present is the third occasion on which the British Association has met in this city, its first meeting here having taken place in the year 1835, or forty-three years ago. On that occasion, as indeed for many years afterwards, the two distinct, though to some extent cognate branches of study, Geology and Geography, were classed in the same Section, and its President was a man of whom Irish science may well be proud, and who, I am thankful to say, is still living to enjoy his well-deserved honours—the veteran geologist, Sir Richard John Griffith, the author of the first Geological Map of Ireland. It seems hardly credible that the construction of this map was commenced in the summer of 1812, or sixty-six years ago; but the records of the Geological Society of London testify to the still more remarkable fact that Sir Richard Griffith was elected a Fellow of that Society in 1808,—seventy years ago. Indeed, in 1854, when the Wollaston medal was awarded to the then Dr. Griffith, the President, the late Professor Edward Forbes, spoke as he said reverentially to one of the earliest members of the Society, and to a geologist who appeared in print before he, the President, was born. It was well said on that occasion that the map lately mentioned was one of the most remarkable geological maps ever produced by a single geologist; and I make no doubt that those who are at present engaged on the Geological Survey of this island will testify, as did their predecessors, to the value of this "surprising monument of observation and skill."

When speaking of the Geological Survey of Ireland, it will not, I am sure, be thought out of place if I offer here a tribute of respect to the memory of one who was originally a student in the College within whose walls we are assembled, and who subsequently occupied posts of the highest importance in connexion with the Geological Society of Dublin and the Geological Survey of Ireland, besides filling the Professorial Chair of Geology in this University: I mean Dr. Thomas Oldham, the late Director of the Geological Survey of India. With the marvellous amount of work which he was enabled to accomplish in that country you are all acquainted, and you will all share in the regret that the period of his well-earned retirement—that "requies optimorum meritorum"—should have been so quickly cut short by death. His name will, however, long survive, and future students of geology will have no difficulty in recognizing the distinguished labourer in their science after whom the Cambrian *Oldhamia* of the Wicklow hills so worthily received its name.

But to return to this Association.

On the next occasion of its meeting in Dublin, in 1857, Section C. had become devoted to Geology alone, and Geography was excluded, the President being Lord Talbot de Malahide, a nobleman whom also we still have among us, and who is alike well known to archæologists and geologists.

As the last meeting of the Association in this city took place twenty-one years ago, it would at first sight appear that in opening our proceedings I might with propriety dwell on the progress which has been made within that period in the development of the geology of Ireland. I must, however, remind you that it is only four years since the Association held its meeting in what I may almost call the neighbouring town of Belfast, when the accomplished chief of the Geological Survey in Ireland presided over this Section and delivered an address, in which some of the more interesting features of the country, especially those of the volcanic district of the north-east of this island, were discussed. During the present year, moreover, he has published his comprehensive work on the Physical Geology and Geography of Ireland, which I commend to you as far more likely to call your attention to the characteristic features of the country and the latest discoveries with regard to its geology than anything I could compile.

In addition to this, there has appeared during the present year another interesting volume, which records the impressions of a highly intelligent foreign geologist on visiting this country. I mean the "Aus Irland" of Dr. Arnold von Lasaulx, Professor of Mineralogy in the University of Breslau. For this volume, in which shrewd remarks on the country and its inhabitants are mingled with geological observations and valuable comparisons of the Irish formations with those of other countries, we are indebted to the meeting of the British Association having been held two years ago at Glasgow, which attracted the author to visit the British Islands.

So much having lately been published upon the geology of this country, I shall content myself with making a very few general observations with regard to it, and propose subsequently to touch briefly on some of those questions which, within the last twelve months, have occupied the attention of those who are engaged in the advancement of our science.

As to the geology of this country, I may observe that we are here assembled just on the edge of that great central plain which forms so important a feature in the map of Ireland, and which stretches from Dublin Bay on the east coast to Galway Bay on the west, with hardly a portion of it attaining to an elevation of three hundred feet above the sea, over a tract of country nearly one hundred and fifty miles in extent in almost every direction.

The boundaries of this great plain and those of the Carboniferous Limestone almost coincide, so that we have here the somewhat remarkable feature of a formation which in England is of such a character as to have received the name of the Mountain Limestone, constituting in the neighbouring island nearly the whole of the plain country. In some of the north-western counties, however, as for instance Fermanagh and Sligo, it assumes its more mountainous character. Nearly the whole of this central plain is overlain with boulder clay, limestone gravel or middle drift, and extensive bogs, so that the subjacent rock is but occasionally seen. In several places detached bosses of Old Red Sandstone rise through the limestone, and there is also good reason for believing, with Professor Hull, that the whole of the area was at one time covered with the upper members of the Carboniferous group, including the true Coal-measures, of which unfortunately but small patches remain, and those upon the margin of the plain. From the absence of the Upper Palæozoic, Mesozoic, and Cainozoic formations over the area, Professor Hull has arrived at the conclusion that the surface remained in the condition of dry land, while that of England was being submerged beneath the waters of the sea, over the bed of which nearly all these formations were deposited. To a certain extent, however, he leaves it an open question whether some of the Mesozoic strata which occur over the north-east of Ireland may not have been deposited over the centre and south. The amount of denudation over this central area has, no doubt, been such that the chances of even Professor Judd finding traces of these later deposits appear at first sight to be but small; but whether the whole of this vast amount of denudation is due to the wasting influence of rain, rivers and other sub-aërial agents of erosion, is a question which I venture to regard as at all events open to discussion. It appears to be the case that in some parts of the North of Ireland the whole of the Upper Carboniferous beds had been denuded before the deposition of any Permian strata, as these are deposited immediately on the Carboniferous Limestone; and if this amount of denudation had taken place in pre-Permian times in the north, there seems a possibility of the same having been the case in Central Ireland. If so, it is possible that some traces of the later deposits may yet be found on the central plain. Certainly, if we are still to regard the White Chalk as a deep-sea deposit, the Cretaceous rocks of the north-east of Ireland must have at one time extended farther south than they do at present, and somewhere or other there must have been shore deposits of that period formed further south than the Upper Greensand of Antrim. The careful investigations of Professor Judd have largely extended our knowledge of the Secondary rocks of the western coast and islands of Scotland, and he has been able to show that the Jurassic series of the Western Highlands could not have had a thickness of less than three thousand feet. It is therefore hard to believe that, with such a development in so closely neighbouring a district, the deposits of the same age in Ireland can have been restricted to their present area.

Professor Judd considers that the amount of denudation in the Scottish Highlands since the Mesozoic and even the Miocene period has been enormous, and that the great surface features of the Highlands were produced in Pliocene times. It seems therefore possible, if not probable, that so long a period of exposure to sub-aërial influence as that assigned to the central plain of Ireland by Professor Hull, would have resulted in a more uneven land surface than that which we now find. At all events, the history of this remarkable physical feature is one which is of high interest, and can hardly as yet be considered as closed.

With regard to the mountainous districts surrounding the central plain, we shall, I believe, have the opportunity of visiting some parts of the Wicklow Mountains, a district from which a portion, at all events, of the native gold of Ireland was procured in ancient times, as indeed it continues to be. Of the abundance of gold in this country in early times, a glance at the magnificent collection of ancient ornaments preserved in the museum of the Royal Irish Academy will serve to give an idea. Even in times more recent than those in which the bulk of these ornaments were made, gold was an important product of this country, and I am tempted to quote a few lines from an early English poem, "The Libell of Englishe Policye," written in the year 1436. In treating of the commodities of Ireland, the author says that the country is

> "So large, so gode, and so commodious
> That to declare is straunge and merveilous.
> For of silver and gold there is the ore
> Among the wilde Irish, though they be pore;
> For they ar rude and can theron no skille
> So that, if we hadde ther pese and good wille,
> To mine and fine and metal for to pure
> In wilde Irishe mighte we find the cure;
> As in Londone saith a jewellere
> Which broughte from thennes gold oor to us here,
> Wherof was fined metal gode and clene,
> That at the touch no better coude be sene."

Sir William Wilde has observed that the south-western half of Ireland has yielded a greater amount of gold antiquities than the north-western, and probably this would hold good with regard to the production of the metal itself, though it has been found in the counties of Antrim, Tyrone, and Derry, as well as in those of Dublin, Wicklow, Wexford, and Kildare.

The north-east of Ireland possesses, however, another geological feature peculiar to itself in that great expanse of volcanic beds which formed the subject of Professor Hull's address to this Section at the Belfast Meeting. My only object in now mentioning them is again to call attention to their containing the only remains of a Miocene flora which are to be found in this island. Analogous beds were detected in the corresponding basalts in the Island of Mull by the Duke of Argyll in 1851. With the exception of the Hempstead beds of the Isle of Wight, which should probably be classed as Oligocene, and the Bovey Tracey beds of Devonshire, these are almost the only deposits of Miocene age in the British Isles. The contrast presented by the scarcity of deposits of this period in Britain with their abundance in the north-west, centre, and south of France, Switzerland, and generally in the South of Europe, is striking. Instead of thick deposits covering hundreds of square miles of country, like the Miocene beds bordering the Pyrenees or those of the great system of the Auvergne, we have small patches owing their preservation either to volcanic outbursts having covered them up, or to some favourable circumstance having preserved them from total denudation. Whether we are to assume, with the late Professor Edward Forbes, that the general dearth of these strata in the British Isles arose from the extent of dry land which prevailed during the long interval between the Eocene and Pliocene periods, or whether we assume the former existence of widespread marine deposits which have since been entirely removed, the case is one not without difficulty. At all events, the absence of representatives of this period within the British area has a tendency to prevent a due appreciation of the enormous extent of the Miocene period being generally felt in this country. Nor, generally speaking, do we, I think, take a fair estimate of the remoteness in time to which we must date back the commencement of that lengthened period. Professor Haughton, judging from the maximum observed thickness of each successive deposit, has calculated that a greater interval of time now separates us from the Miocene period than that which was occupied in producing all the Secondary and Tertiary strata from the Triassic to the Miocene epoch, and, without endorsing the whole of my accomplished friend's conclusions, I incline to concur in such an estimate. When it is considered that the Ballypalidy beds of Antrim and the Lough Neagh clays are the sole representatives in Ireland of two periods of such length and importance as the Miocene and Pliocene, their high interest will be more apparent, and I trust that no opportunity of minutely studying them will be neglected.

There is one other point with regard to Irish geology on which it will be well to say a few words, though it is of a negative rather than a positive character. I mean the absence, so far as at present known, of Palæolithic implements in this country. It is true that Professor Hull, in the book to which I am so much indebted, speaks of a raised beach on the Antrim coast as containing worked flints of that rude form and finish known as Palæolithic; but this is a slip of the pen, by which the author has fallen into the not uncommon error of applying a term which is merely significant of the age of the implements to their external character. However rude may be the workmanship of the flint implements found at Kilroot, they belong to the Neolithic, and not to the Palæolithic period. So far as I am aware, no example of any implement belonging to the age of the Mammoth, Rhinoceros and other members of the Quaternary fauna has as yet been found in Ireland. Indeed, the remains of *Elephas primigenius* and its associates are of exceedingly rare occurrence in this country, though they have been found with those of Bear and Reindeer in the Shandon Cave near Dungarvan. It is, of course, impossible to foretell what future researches may bring to light; but judging from analogy, it seems hardly probable that until ancient river-gravels containing the remains of the Quaternary group of mammals are found in this island, veritable Palæolithic instruments will be discovered. The association of the two classes of remains is so constant that we may fairly assume that the animals formed the principal food of the Palæolithic hunters, and that any causes which lead to the absence of the one class will lead to the absence of the other also.

There is, however, one member of that old Quaternary group which is far more abundant in Ireland than it is in England or on the Continent of Europe—the *Megaceros*—which has rightly received the appellation of *Hibernicus*.

I hope that we may have an opportunity, under the guidance of Mr. Richard Moss, of seeing some of the remains of this "antlered monarch of the waste" in the position in which they were originally interred, and it will be an interesting question for consideration whether these remains can be regarded as of the same geological age as those of the English caves and river-gravels, or whether they do not for the most part belong to what Professor Boyd Dawkins has termed the Pre-historic period. It seems by no means improbable that this gigantic stag survived in this country for ages after he had become extinct in other lands, and that the view held by Professor Hull of his extinction being due to persecution by man is correct. If this be so, it would seem to follow that the human occupation of Ireland is of far more recent date than that of the sister country.

And this brings me to one of those questions which have of late been occupying the attention of geologists. I mean the date which is to be assigned to the implement-bearing beds of Palæolithic age in England. Dr. James Geikie has held that for the most part they belong to an interglacial episode towards the close of the Glacial period, and regards it as certain that no Palæolithic bed can be shown to belong to a more recent date than the mild era that preceded the last great submergence.

His follower, Mr. Skertchly, records the finding of Palæolithic implements in no less than three interglacial beds, each underlying Boulder-clays of different ages and somewhat different characters, the Hessle, the purple, and the chalky Boulder-clay. This raises two main questions, first, as to how far Dr. Croll's theory of the great alternations of climate during the Glacial period can be safely maintained; and secondly, how far the observations as to the discovery of implements in the so-called Brandon beds underlying the chalky Boulder-clay can be substantiated. Another question is how far the Palæolithic deposits can be divided into those of modern and ancient valleys, separated from each other by the purple Boulder-clay, and the later of the two older than the Hessle beds. It would be out of place here to discuss these questions at length. I will only observe, that in a considerable number of cases the gravels containing the implements can be distinctly shown to be of much later date than the chalky Boulder-clay, and that if the implements occur in successive beds in the same district, each separated from the other by an enormous lapse of time, during which the whole country was buried beneath incredibly large masses of invading ice, and the whole mammalian fauna was driven away, it is a very remarkable circumstance. It is not the less remarkable because this succession of different Palæolithic ages seems to be observable in one small district only, and there is as close a resemblance between the instruments of the presumedly different ages as there is between those of admittedly the same date. I have always maintained the probability of evidence being found of the existence of Man at an earlier period than that of the post-Glacial or Quaternary river-gravels, but, as in all other cases, it appears to me desirable that the evidence brought forward should be thoroughly sifted and all probability of misapprehension removed before it is finally accepted. In the present state of our knowledge, I do not feel confident that the evidence as to these three successive Palæolithic deposits has arrived at this satisfactory stage. At the same time it must be borne in mind that if we make the Palæolithic period to embrace not only the river-gravels but the cave deposits of which the South of France furnishes such typical examples, its duration must have been of vast extent.

In connexion with the question of Glacial and Interglacial periods, I may mention that of climatal changes in general, which has formed another subject to which much attention has of late been given. The return of the Arctic Expedition, and the reports of the geological observations made during its progress, which have been published by Captain Fielden, one of the naturalists to the Expedition, in conjunction with Mr. De Rance and Professor Heer, have conferred additional interest on the question of possible changes in the position of the poles of the earth, and on other kindred speculations. Near Discovery Harbour, about latitude 81° 40′, Miocene beds were found containing a flora somewhat differing from that which was already known to exist within the Arctic regions. "The Grinnell Land lignite," say the authors of the report, "indicates a thick peat moss, with probably a small lake, with water lilies on the surface of the water, and reeds on the edges, with birches, poplars, and taxodiums on the banks, and with pines, firs, spruce, elms, and hazel-bushes on the neighbouring hills." When we consider that all of the genera here represented have their present limits at least from twelve to fifteen degrees farther south, while the taxodium is now confined to Mexico and the south of the United States, such a sylvan landscape as that described seems entirely out of place in a district within six hundred miles of the pole, to which indeed, if land then extended so far, these Arctic forests must have also extended in Miocene times. Making all allowance for the possibility of the habits of such plants being so changed that they could subsist without sunlight during six months of a winter of even longer duration, I cannot see how so high a temperature as that which appears necessary, especially for the evergreen varieties, could have been maintained, assuming that Grinnell Land was then as close to the North Pole as it is at the present day. Nor is this difficulty decreased when we look back to formations earlier than the Miocene, for the flora of the Secondary and Palæozoic rocks of the Arctic regions is identical in character with that of the same rocks when occurring twenty or thirty degrees farther south, while the corals, encrinites, and cephalopods of the Carboniferous Limestone are such as, from all analogy, might be supposed to indicate a warm climate.

The general opinion of physicists as to the possibility of a change in the position of the earth's axis has recently undergone modifications somewhat analogous in character to those which, in the opinion of some geologists, the position of the axis has itself undergone.

Instead of a fixed dogma as to the impossibility of change, we find a divergence of mathematical opinion, and variations of the pole, differing in extent, allowed by different mathematicians who have of late gone into the question, as for instance the Rev. J. F. Twisden,[1] Mr. George Darwin,[2] Professor Haughton,[3] the Rev. E. Hill,[4] and Sir William Thomson.[5] All agree in the theoretical possibility of a change in the geographical position of the earth's axis of rotation being effected by a redistribution of matter on the surface, but they do not appear to be all in accord as to the extent of such changes. Mr. Twisden, for instance, arrives at the conclusion that the elevation of a belt twenty degrees in width, such as that which I suggested in my Presidential Address to the Geological Society in 1876, would displace the axis by about ten miles only, while Professor Haughton maintains that the elevation of two such continents as Europe and Asia would displace it by about sixty-nine miles, and Sir W. Thomson has not only admitted, but asserted as highly probable, that the poles may have been in ancient times "very far from their present geographical position, and may have gradually shifted through ten, twenty, thirty, forty, or more degrees without at any time any perceptible sudden disturbance of either land or water."

I am glad to think that this question, to which I to some extent assisted to direct attention, has been so fully discussed, but I can hardly regard its discussion as being now finally closed. It appears to me doubtful whether eventually it will be found possible to concede to this globe that amount of solidity and rigidity which at present it is held to possess, and which to my mind at all events seems to be in entire disaccordance with many geological phenomena. Yet this, as the Rev. O. Fisher[6] has remarked, is presupposed in all the numerical calculations which have been made. I am also doubtful whether, in the calculations which have been made, sufficient regard has been shown to the fact that a great part of the exterior of our spheroidal globe consists of fluid which, though of course connected with the more solid part of the globe by gravity, is readily capable of readjusting itself upon its surface, and may, to a great extent, be left out of the account in considering what changes might arise from the disturbance of the equilibrium of the irregular spherical or spheroidal body which it partially covers. It appears to me also possible that some disturbances of equilibrium may take place in a mysterious manner by the redistribution of matter or otherwise in the interior of the globe. Captain F. J. Evans,[7] arguing from the changes now going on in terrestrial magnetism, has suggested the possibility of some secular changes being due to internal, and not to external causes; and if it be really true that there is a difference between the longest and shortest equatorial radii of the earth, amounting to six thousand three hundred and seventy-eight feet,[8] such a fact would

[1] Quart. Journ. Geol Soc., 1878, p. 35.
[2] Proc. R. S., vol. xxv. p. 328. Phil. Trans., vol. clxvii. p. 271.
[3] Proc. R. S., 1877, 1878.
[4] Geol. Mag., June, 1878.
[5] Rep. Brit. Assoc., 1876, p. 11.
[6] Geol. Mag., July, 1878.
[7] *Nature*, May 16, 1878.
[8] Thomson and Tait, Phil. p. 648.

appear to point to a great want of homogeneity in the interior of our planet, and might suggest a possible cause for some disturbance of equilibrium.

I have mentioned Professor Haughton among those who, from mathematical considerations, have arrived at the conclusion that a geographical change in the position of the axis of rotation of the earth is not only possible, but probable. In a recent paper, however, he has maintained, notwithstanding this possibility or probability, we can demonstrate that the pole has not sensibly changed its position during geological periods. He arrives at this conclusion by pointing out that in the Parry Islands, Alaska and Spitzbergen, there are Triassic and Jurassic deposits of much the same tropical character, and then by a geometrical method fixing the North Pole somewhere near Pekin, and the south pole in Patagonia, within seven hundred miles of a spot where Jurassic ammonites occur, shows that such a theory is untenable. In the same way he fixes the pole in Miocene times near Yakutsk, within eight hundred miles of certain Miocene Coal-beds of the Japanese islands. These objections are at first sight startling, but I think it will be found that if, instead of drawing great circles through certain points, we regard those points as merely isolated localities in a belt of considerable width, there is no need of fixing the pole of either the Jurassic or the Miocene period with that amount of nicety with which Professor Haughton has ascertained its position. The belt may indeed be made to contain the very places on which the objection is founded. Still the method proposed is a good one, and I hope that as our knowledge of foreign geology extends it may be still further pursued. There is, however, one farther consideration to be urged, and that is as to the safety of regarding all deposits of one geological period as contemporaneous in time. Although an almost identical flora may be discovered in two widely-separated beds, it appears to me that chronologically they are more probably of different ages than absolutely contemporaneous; and, inasmuch as the duration of the Miocene period must have been enormous, there would be time—if once we assume a wandering of the poles—for such wandering to have been considerable between the beginning and end of the period.

I must not, however, detain you longer upon this phase of geological speculation, but will advert to a subject of more practical interest, the discovery of Palæozoic rocks under London. So long ago as 1856 the Kentish Town boring had shown that immediately below the Gault red and variegated sandstones and clays occurred, which Professor Prestwich regarded as probably of Old Red or Devonian age. The boring of Messrs. Meux & Co. has now shown that under Tottenham Court Road, at a depth of little more than nine hundred feet from the surface, there are true Devonian beds, with characteristic fossils, and that Mr. Godwin-Austen's prophecy of the existence of Palæozoic rocks at an accessible depth under London has proved true. Professor Prestwich, from a consideration of the French and Belgian coal-fields, inclines to the belief that in the district north of London Carboniferous strata may be found. Unfortunately the expense of conducting deep borings, even with the admirable appliances of the Diamond Boring Company, is so great that I almost despair of another experimental borehole like that carried out in the Wealden district under the auspices of Mr. Willett, being undertaken.

In the department of theoretical geology I would call your attention to some experiments by M. Daubrée, of which he has given accounts at different times to the French Academy of Sciences. In these experiments he has attempted to reproduce on a small scale various geological phenomena, such as faulting, cleavage, jointing, and the elevation of mountain chains. Although the analogy between work in the laboratory and that on the grand scale of nature may not in all cases be perfect, yet these experiments are in the highest degree instructive, and reflect no little credit on the ingenuity of the distinguished chief of the École des Mines.

With regard to recent progress in palæontology, I must venture to refer you to Professor Alleyne Nicholson's inaugural address lately delivered to the Edinburgh Geological Society, but I cannot pass over in silence the magnificent discoveries in North America, which are principally due to the researches of Professors Marsh, Leidy, and Cope. The *Diceratherium*, a rhinoceros with two horns placed transversely, and the *Dinoceras*, somewhat allied to the elephant, but with six horns, arranged in pairs, are as marvellous as some of the beasts seen by Sir John Maundevile on his travels, or heard of by Pliny. But perhaps the most remarkable series of remains ever discovered are those which so completely link the existing Horse with the *Eohippus* and *Orohippus*, and still farther extend the pedigree of the genus *Equus*, which had already been some years ago so ably traced by Professor Huxley.

Of these American discoveries, as well as those made in the Tertiary beds of Europe, M. Albert Gaudry has largely availed himself in his recent beautiful volume on the links in the animal world in geological times, a work which will long be a text-book on the inter-relation of different orders, genera, and species. I am tempted to make use of some portions of M. Gaudry's own analysis of the book, which he communicated to the Geological Society of France. Beginning with the Marsupials of the close of the Secondary and beginning of the Tertiary period, he shows that they are succeeded by such animals as the *Pterodon*, the *Hyænodon*, the *Proviverra*, and *Arctocyon*, which present a mixture of marsupial and placental characters, and to some extent justify a theory of the transition from one order to the other. He next examines the marine Mammalia, and points out that, so far as at present known, they make their appearance later than those of the land, and that the examination of the pelvis of the *Halitherium* tends to support the idea that the mammals, such as the Sirenians, which at the present day have no hind-limbs, are descended from terrestrial quadrupeds, for those limbs in the *Halitherium* are much less reduced than in its recent successors, the dugong and manatee. After tracing the numerous links which are to be found between the extinct and living Pachydermata, he proceeds to show that, notwithstanding the great distance between them and the Ruminants, transitions may be seen. The earliest ruminants were devoid of horns and antlers, but possessed upper incisors, and by a comparison of the molars of different genera it may readily be conceived how the large bosses of the omnivorous teeth of the pachyderms gradually shaded into the small crescents of the teeth of the ruminants. At the same time the passage from the heavy and complicated extremities of the limbs of the pachyderms to the simpler and lighter feet of the ruminants can be traced. The history of the Horse family is also discussed, and the descent of existing proboscidians from the mastodonts is shown to be probable, though the previous forms from which the mastodonts and dinotheria are derived are as yet unknown. Nor can the origin of the Carnivora as yet be suggested, though passages between the six existing families of the order may be observed. In conclusion, M. Gaudry devotes a chapter to the Quadrumana, and thinks that palæontological observations tend to diminish the isolation in which these mammals now stand with regard to the other orders.

One of the most important features insisted on by Mons. Gaudry is that to which I have already alluded—the development of the complicated molars of most mammals. His view is that by a comparison with early and with fœtal forms the probability may be shown of these compound teeth being made up of what in earlier forms were simple teeth—or, as he termed them, denticules—which have coalesced in the same manner as have some other parts of the normal bony skeleton. In the compound teeth the denticules in some cases preserve their original conical form, as in the pig tribe; in others are elongated transversely, so as by their junction to form ridges, as in the tapirs; while in others, again, they are drawn out into longitudinal crescents, as in the ruminants. Between these forms there are, of course, innumerable transitions. They do not, however, appear to me to affect the importance of Mons. Gaudry's observations, which must be regarded as of the highest value in all attempts to trace the inter-relation of different forms of mammalian life. I must not, however, detain you longer on this subject, as I trust that I have said enough to show the importance and interest of this book.

The discoveries of early forms of birds with teeth do not come within M. Gaudry's province; but Professor Marsh has largely added to our knowledge of these remarkable forms. The Tertiary *Odontopteryx toliapicus* from Sheppy, described by Professor Owen, seems rather to be endowed with bony tooth-like processes in the jaw, than actual teeth, and the head of the *Argillornis* from the same locality is at present unknown. But the *Hesperornis* and *Ichthyornis* from the Cretaceous beds of America possess veritable teeth, in the one case set in a long groove in the jaw, and in the other in actual sockets. Such intermediate, or, as Professor Huxley would term them, intercalary forms, tend materially to bridge over the gap which at first sight appears to exist between reptiles and birds, but which to many palæontologists was far from being impassable, long before the discoveries just mentioned. The amphicœlous character of the vertebræ of *Ichthyornis* presents another most remarkable peculiarity, which is also of high significance. I hear rumours of the discovery of another *Archæopteryx* in the Solenhofen Slates, which is said to present the head in a much more complete condition than that in which it occurs on the magnificent slab now in the British Museum. As yet, I believe, the jaws have not had the matrix removed from them; but should they prove to be armed with teeth, it will to me be a cause of satisfaction rather than surprise, as confirming an opinion which some fifteen years ago[1] I ventured to express, that this remarkable creature may have been endowed with teeth, either in lieu of or combined with a beak.

I must not, however, detain you longer with any of these general remarks, which are, moreover, becoming somewhat egotistic, but will now proceed to the business of this Section, in which I hope that more than one paper of great value and interest will be forthcoming.

## CORRESPONDENCE.

### THE MONTE GENEROSO BEDS.

SIR,—The French Geologist who supplied information to your correspondent, the Rev. E. M. Cole, respecting the age of these beds (GEOL. MAG., Decade II. Vol. V. p. 378), provided him with an order of succession which has been well known for many years. But if the divisions and their relative positions be clear enough, their correlation with members of the Mesozoic series in England is fraught with considerable difficulty.

The Como deposits in question include all the representatives of the Lias and Oolites and something more. Taking them one by one in descending order, as given by Mr. Cole's informant, we have:

1. *Majolique:* A white compact limestone, the celebrated *Majolica* marble of the Italians. This must not be mistaken for the very similar *Biancone*, which was for a long time confounded with it, but which is now known to be of Neocomian age, and consequently newer than the *Majolica.* The latter is not only like Chalk in appearance, but is, like it, also characterized by the presence of flints in nodules and bands; it is often dolomitic and contains but few fossils, principally *Trigonellites* and rarely *Ammonites.*
2. *Calcaire rouge:* The *Calcare rosso ammonitifero* of Lombardy, not altogether the representative of the division which goes by that name in the Apuan Alps. This red deposit teems with Ammonites of species which, to the confusion of the palæontologist, are elsewhere characteristic of various horizons from the Lower Lias to the Upper Oolite.

[1] Nat. Hist. Rev., vol. v. p. 421. According to Dr. Haberlein, the possessor of the second specimen, *the jaws are armed with teeth!* thus confirming Dr. John Evans's opinion founded on an examination of the specimen preserved in the British Museum; where, on the slab of stone which contains it, a small detached jaw with teeth is to be seen lying.—EDIT. GEOL. MAG.

3. *Calcaire gris* (not *grès*): The ornamental marble of Saltrio, containing *Ammonites Bucklandi.*
4. *Calcaire noir*: The black marble of Varenna. This is the base of the "*Jura Lombard.*" Beneath it occur in places, and especially between Lakes Lugano and Como, (5) some extremely interesting black fossiliferous shales, which have been referred to the St. Cassian Group by Escher v. d. Linth. Below these again comes
6. The *Conglomérat marneux:* in which fossils are not known, but which is referred to the Keuper horizon by Omboni.

How very different a set of deposits we have here from anything to be found in England between Trias and Neocomian will be seen at once; but if an attempt at correlation could serve any useful purpose, it would be something like this:

| | |
|---|---|
| Biancone. | Lower Neocomian of Speeton. |
| Majolica. | Portlandian.<br>Kimmeridgian.<br>Corallian.<br>Oxfordian.<br>Lower Oolite. |
| Calcare rosso ammonitifero (= *Calcaire rouge*). | Upper, Middle, and Lower Lias (in part). |
| Marmo di Saltrio (= *Calcaire gris*). | Lower Lias (*Ammonites oxynotus* and *Amm. Bucklandi* horizons). |
| Calcare degli stampi (= *Calcaire noir*). | White Lias. |
| Guggiate Beds. | Rhætic. |
| Green and Red Marls (= *Conglomerat marneux*). | Keuper. |

It should be noted that all these divisions are perfectly conformable, and that, notwithstanding the very marked difference in colour, the white majolica and the red ammonite bed are, palæontologically speaking, one continuous whole.

Much information (and extremely varied, for no two, of the earlier authors at least agree in their interpretation of the facts) on this subject will be found in the papers of Pasini, Catullo, Curioni, de Filippi, de Collegno, Omboni, etc. From a paper by the last-named geologist, much of the above matter is taken.

The "*Calcare rosso*" of the Apuan Alps, the vicissitudes of which I described in 1876,[1] appears to be probably the equivalent of the *Marmo di Saltrio.*

G. A. Lebour.

2, Woodhouse Terrace, Gateshead-on-Tyne.

[1] "The Carrara Marbles," Geol. Mag., Decade II. Vol. III. p. 289.

PROFESSOR PHILLIPS ON THE DEVONIAN QUESTION.

Sir,—The address delivered in 1869, by John Phillips, at Westward Ho! and which has just been communicated by Mr. Hall (see Geol. Mag., July, 1878, p. 307), seems to contain the latest views of that geologist upon the Devonian rocks, though not, I believe, his latest expression of them. A more recent statement is given in the "Geology of Oxford and the Valley of the Thames" (1871), pp. 79, 80. As far as I can understand, these views of Prof. Phillips do not differ so very materially from those advocated by Jukes. In the address just mentioned, Phillips says, "Gentlemen of Devon, never give up the independence of your country, hold to the North Devon series, and if it is the case, as Mr. Godwin-Austen invites us to believe it is, that they do not belong to the Old Red Sandstone series, do not let us conclude that because they do not belong to that particular class, they are nothing at all."

In the "Geology of Oxford," etc., are the following passages, "The Old Red Sandstone is followed in Devonshire, and still more remarkably in the South of Ireland, by a series of shales, grits, and limestones, with a large suite of fossils, having on the whole a considerable analogy with the still richer associations of marine life in the Carboniferous Limestone. . . . . Near Linton, in North Devon, and south of Plymouth, we may satisfy ourselves of the fact that Old Red Sandstone underlies the Devonian beds. . . . . From this series of rocks to the Carboniferous strata which succeed, the transition is easy, so easy indeed that, in the opinion of Sir R. Griffith and Mr. Jukes, the whole of the Devonian series may be united with the lowest members of the Irish Carboniferous group (Yellow Sandstone and Carboniferous shale). What seems ascertained truth is the close approximation in time, in character of deposition, and in forms of life, of the South Hibernian and South Welsh rocks; while the North Devonian strata contain with these a somewhat lower group, not distinctly represented in Wales or Ireland." [1]

Here, then, we find that Professor Phillips would separate the Old Red Sandstone from the Devonian rocks, while he speaks of the Devonian fauna as "continued into the cognate though later Carboniferous Period." I think by the term Carboniferous Period, as here used, Professor Phillips referred especially to the fauna of the Carboniferous Limestone. But his views, so cautiously expressed, seem to approximate towards those of Jukes, and to render their differences chiefly a question of terms or classification. Certainly they are distinct from the contention of Mr. Etheridge, "that the Devonian system, as a group of strata, both physically and palæontologically, may be (as long ago proposed) naturally and conveniently divided into a Lower, a Middle, and an Upper Series, and that there is valid reason for believing that this system equalled in time the whole of the deposits of the Old Red Sandstone proper." (Quart. Journ. Geol. Soc., vol. xxiii. p. 686.) A statement which is perhaps a little modified by a subsequent admission (p. 690) that,

[1] These remarks were quoted by me in a review of the Devonian Question, Quart. Journ. Science, Jan. 1873.

"On the other hand, there may be grounds for endeavouring to establish contemporaneity between the Upper Devonian series of North Devon and the Carboniferous Slates of the South of Ireland, upon the principle of geographical rather than chronological distinction."

Guided by the opinion of Professor Phillips, we should certainly be warranted in keeping distinct the application of the terms Old Red Sandstone and Devonian, which, when used synonymously, are productive of much confusion. In this case of course the Lynton Sandstone (Foreland Group) of North Devon should be classed as Old Red Sandstone, and excluded from the Devonian system.

MOUSEHOLD, NORWICH, 10*th August*, 1878. HORACE B. WOODWARD.

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"COAST ICE ON A RISING AREA." REPLY TO DR. G. LINNARSSON.

SIR,—Two days ago, on returning from a long geological excursion which I had been making in the interior of Japan, I received several numbers of the GEOLOGICAL MAGAZINE. In the Number for February I read the letter of Dr. G. Linnarsson of Stockholm, criticizing my views of glacial phenomena which appeared in a series of articles in your MAGAZINE, under the title "Across Europe and Asia." If Dr. Linnarsson had awaited the completion of my article, or if he had only carefully interpreted those portions of it that were in his possession at the time he wrote, I think he would have seen that he was campaigning against an imaginary foe.

He has failed to observe that my travelling notes are only a series of fragmentary jottings collected and subsequently written out under considerable difficulties. Under such circumstances, feeling my fallibility, I held myself open to correction, and it is therefore now with pleasure that I thank Dr. Linnarsson for having incidentally pointed out my *oversight* in ascribing the presence of erratics at higher levels than their parent rock to the action of coast-ice on a *rising* area.

I say oversight, advisedly, first because this is a phenomenon which is so universally referred to by all writers on these subjects, and secondly because previously I myself, in the GEOLOGICAL MAGAZINE, Dec. II. Vol. III. Nos. 7, 8, and 9, when writing more generally upon coast-ice, have referred to these appearances as being due (as many before me have suggested) to the action of coast-ice on oscillating or sinking areas. For example, in one place I make the following note: "Other blocks again are shown to have travelled from low plains to the summit of hills, which is explained on the supposition that the land at the time of their deposit was slowly subsiding, and the ice-fields of successive years were raising the blocks higher and higher."

With regard to the remainder of Dr. Linnarsson's criticisms, which form the substance of his correspondence, I hardly feel that I can acquiesce in the manner in which he has treated my communication. One of my chief objects, when speaking of the appearances which I saw along the coast of Finland, was to show that it was by no means necessary for us to imagine that every surface which had been scratched and rounded must have been produced by a continental sheet of ice, and it was only to explain *some* of these phenomena that I suggested an agency which I believe has been hitherto overlooked, namely, that of coast-ice upon a rising area.

Dr. Linnarsson seems to say that from observations made from railway waggons and steamers I think myself "enabled to refute the views since many years universally held by Scandinavian geologists."

If he had only read my paper attentively, he would have seen that my views respecting the glaciated appearance of low countries like that I saw in Finland are by no means only founded on what I saw from the railway waggons of Scandinavia and the steamers of Finland, but also from observations made upon the shores of some "4000 miles of coast in Labrador and Newfoundland."

To convince Dr. Linnarsson that I am not acting so impulsively as he would give the readers of the Geological Magazine to understand, I may refer him to several other papers which I had previously written upon the same subject (see Geol. Mag., Decade II. Vol. III. 1876, pp. 303, 345, 408; see also Quart. Journ. Geol. Soc. 1877, vol. xxxiii. p. 929). If, even without reading these papers, he had only waited until the completion of my travelling notes, he would have saved himself the necessity of proving the former existence of a glacial climate.

In several portions of my paper I very distinctly incline towards what Dr. Linnarsson would make me appear to be so antagonistic to. Thus, for example, in the Geological Magazine, February, 1878, near the end of my paper, I most clearly state that my arguments antagonistic to the existence of polar ice caps have "only been in regard to the production of certain phenomena." Amongst these apparent glacial phenomena are appearances which may be seen in many portions of the world along coast-lines, islands and low-lying countries, and as illustrations of these I have taken portions of Finland, Labrador, and Newfoundland. Dr. Linnarsson admits the abrading power of coast-ice, and I also think that, in common with other geologists, he will admit that there is such a phenomenon as the slow elevation of the land. If he does this, I think he must then admit the existence of those effects which must result from the combined influence of these two agents. That *all* the so-called glacial phenomena to be seen in Sweden and other countries are by any means to be attributed to this action, I by no means wish to advocate, but at the same time I must confess that I should find it difficult to prove that the scratches and furrows which I have often seen upon a coast-line, and which the inhabitants tell me were produced by the shore ice of last winter, were the consequence of some continental glacier which may have perhaps existed some 10,000 years ago. It would be equally antagonistic to my sense of reason to endeavour to prove a similar origin for the furrows and scratches which in a rising area graduate upwards and backwards from those produced last year at the water's edge.

The chief point which I wished to advocate in my paper was that the action of coast-ice on a rising area has produced many phenomena which are inexplicable by the action of continental glaciers. On the other hand, Dr. Linnarsson shows that there are phenomena which I did not even refer to in my paper that may have been produced by a continental sheet of ice, but not by coast-ice.

To all this I see no objection, and so long as Dr. Linnarsson only claims a reasonable proportion of the so-called glacial phenomena as the result of the action of his continental sheet, I shall be content to see the leavings sifted and a certain proportion of them set down to the credit of coast-ice acting on a rising area.

So much then for the general argument embraced in Dr. Linnarsson's communication. I will now turn to one or two of his details.

First, I cannot agree with Dr. Linnarsson that the scratches produced by coast-ice are "independent of the slope of the land." In making this statement, it appears to me that he has apparently omitted to notice the most effective of the methods in which coast-ice acts. Looking at a coast-line generally, the slope of the land will be at right angles to its direction, and the scratchings and furrowings due to the action of ice being produced by the driving in or "raftering" of the pack-ice upon the ice-foot or "balacada," the markings which are produced must be parallel to this movement, that is, at right angles to the shore-line. If, on the other hand, the "currents and winds" are very oblique or parallel to the coast-line, the balacada will usually remain unmoved, and will only be chafed as the pack-ice floats along its outer edge, or what the inhabitants of Labrador and Newfoundland call the "drain."

If we consider the way in which scratchings are produced by the dragging and sliding of coast-ice back towards the sea, and say the markings which will remain behind are independent of the slope of the land, we shall next, perhaps, be induced to say that the direction in which rain runs from the roof of a house is also independent of the direction of its greatest slope.

At the commencement of Dr. Linnarsson's letter, when speaking of my arguments, he says, "I think that most of your readers do not need to have the failings of such reasonings pointed out." The reasons here referred to are my arguments in reference to the action of coast-ice. What must the readers of the Geological Magazine think of the authoritative statements and arguments of Dr. Linnarsson, when they read at the termination of his letter that "The rocks (on the coasts of Sweden and Finland) are there so hard and compact, and the force of the waves so small, that their action on the rock surface is hardly perceptible. A rock may be exposed there for hundreds of years to the waves without the finest scratches being abraded." Whilst remembering that a rock exposed to the waves must also be exposed to the atmosphere, six lines further on they then read that, "In the open air the scratches usually become obliterated in a few years," etc.?

All this is brought forward, I may mention, in opposition to an opinion I expressed that all glaciated rocks, in order that their scratched surfaces may retain their character, "must always have remained above sea-level or else have been shielded by some protective covering during both subsidence and elevation," a view from which I do not yet see the slightest reason to waver. If the country is a cold one, such for example as we might imagine during the retreat of a continental covering of ice from the face of Sweden, and depression were taking place, coast-ice, it seems to me, would grind every furrow from the surface of the rocks, as they gradually sank down at any particular time, the abrading action taking place from a level above that of high water to one below low water, and every portion of the surface of the country being many thousands of years in sinking through the abrasion region. On elevation this erasing action would be repeated. If the country were not a cold one, atmospheric agencies, a continual exposure to an artillery of pebbles, the grinding of sand, and like causes, would, according even to the most modest calculations, have sufficient time for the production of a similar result. JOHN MILNE.

YEDO, *June* 17, 1878.

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## THE QUARTZITES OF THE BUNTER CONGLOMERATE.

SIR,—As I happen to be very familiar with the quartzites of the Bunter Conglomerate of the Midland Counties, may I be allowed to question the correctness of one or two statements which have been lately made in the pages of the GEOLOGICAL MAGAZINE. 1. I cannot admit that the typical quartzite of this Conglomerate is lithologically identical with that from Budleigh Salterton. 2. I greatly doubt whether the fossiliferous pebbles from the Birmingham Drift, now in Jermyn Street Museum, have been derived from the Bunter Conglomerate. At any rate, the rock, though a quartzite, does not appear to me that of the Bunter pebbles: it more nearly resembles that from the Lickey. 3. I have many times searched for fossils in the pebble beds of Staffordshire, and have only twice found them: these were obscure annelid burrows. Hence I cannot admit that there is any palæontological identity with the Budleigh Salterton rock. From physical considerations it would require very strong evidence to induce us to believe that the Midland Counties pebbles came from S. Devon. I have no doubt Professor Hull is right in assigning to them a northern origin (Permian and Trias of Midland Counties, p. 60). I have myself identified them in more than one place in Scotland. For example, they abound in a conglomeratic red sandstone of Lower Carboniferous age in Arran, mixed, however, with fragments of schist, greywacke, etc. These softer rocks have almost invariably perished on the southward journey—so that it is a case of survival of the most durable. T. G. BONNEY.

ST. JOHN'S COLLEGE, CAMBRIDGE, *Aug.* 12.

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## RICHARD DAINTREE, C.M.G., F.G.S.

Born December, 1831. Died June 20, 1878.

Australian Geology has sustained another severe loss in the death of Mr. R. Daintree, C.M.G., F.G.S., following, as it has done, so rapidly on that of the Rev. W. B. Clarke, F.R.S.[1]

Richard Daintree was born at Hemingford Abbotts, Huntingdonshire, in December, 1831, and was educated at the Bedford Grammar School, and Christ's College, Cambridge. In consequence of delicate health, Mr. Daintree was recommended a voyage to Australia, and he accordingly set sail for Melbourne, where he landed in the latter part of 1852. A taste for scientific pursuits brought him in contact with Mr. A. R. C. Selwyn, the Government Geologist of Victoria, whose Assistant he became in 1854; but finding that a more practical acquaintance with Chemistry and Assaying, than he at that time possessed, would prove beneficial to his prospects, he returned to England in 1856, and entered Dr. Percy's Laboratory. Here he worked from November, 1856, to May, 1857, and became a practised and efficient assayer, to which he added a knowledge of practical photographic chemistry.

In August, 1857, Mr. Daintree returned to Melbourne, and in 1858 was appointed Field-Geologist on the Geological Survey of Victoria, which had by this time been established on a firm basis through the energy of its Director, Mr. A. R. C. Selwyn, F.R.S. During his connexion with the Victorian Survey, for the next seven years, Mr. Daintree was occupied in field work and exploration of no ordinary nature. He commenced in the Western-port district, directing his attention to the Cape Patterson Coal Series. In exploring the Bass River, Daintree underwent much hard camp life, and endured many privations in penetrating the dense scrubs of that district.

The Geology of the Bellerine District[2] next engaged Mr. Daintree's attention, lying between Geelong and Queenscliff. A series of extensive borings for Coal, through the Mesozoic rocks, were there superintended; but, although about 4000 feet of strata were passed through, the search was fruitless. On leaving Bellerine in 1861, Mr. Daintree was joined by Mr. C. S. Wilkinson (now Government Geologist for N. S. Wales) as his Assistant, and until March, 1864, they were conjointly engaged in the geological survey of the country from Bass' Straits on the south, to Bacchus Marsh on the north, including the important agricultural and pastoral districts of the Barrabool Hills, the Annakie Hills, the Werribee River and Ballan district. At the end of May, 1863, a most important report was prepared by Mr. Daintree, on this work, and when published it

[1] See Obituary Notice of Rev. W. B. Clarke, Geol. Mag. August, p. 379.

[2] Report on the Geology of Bellerine and Pagwit, with Special Reference to the probable Existence of workable Coal Seams in those Parishes. By R. Daintree.—Vict. Geol. Survey Report, 1861–62, No. 43, folio, pp. 16–23. Melbourne.

*Maps.*—Sheet 23 N.E. (Portarlington); 23 S.E. (St. Leonards); 23 S.W. (Point Henry); Sheet 29 N.E. (Queenscliff); 29 N.W. (Lake Connewarre). By R. Daintree, under the direction of A. R. C. Selwyn.

was prefaced with the following official remarks: "The following interesting Report . . . . contains so much matter having an immediate reference to the economic development of the Colony, interwoven with purely scientific observations, that it has been deemed desirable to publish it *in extenso*, without waiting to produce it in connexion with a series of similar reports or memoirs," etc.

Some of the less known parts of Victoria were explored by Messrs. Selwyn and Daintree in company, and on one of these trips a tour of the gold-fields was made, and many most interesting photographs illustrative of gold-field geology were taken.

In 1864 Daintree resigned his connexion with the Victorian Civil Service, and entered into pastoral pursuits on the River Clarke, Burdekin River, North Queensland; but during one of the several trips made by him about that time between Melbourne and the northern colony, he found time to make a partial examination of the N. S. Wales Coal-field. The results of his observations[1] are important, because they tended in a great measure to support the views held by the late Rev. W. B. Clarke on the age and position of the Coal-measures of N. S. Wales. Notwithstanding the danger and hardships of a "squatting" life in lat. 19° S., Mr. Daintree's geological studies were not neglected, for several useful examinations of his own district were made. In 1866 a paper was read by him before the Royal Society of N. S. Wales, to the effect that auriferous tracts would be found in the neighbourhood of the Endeavour River, a statement which was borne out eight years later by the discovery of the Palmer Gold-field.

The full report,[2] previously referred to, bearing on the work done by Daintree and Wilkinson in the Ballan district of Victoria, was not published in detail until 1866, when it appeared as one of the regular reports of the Survey. In this report Daintree discussed at some length the various modes of occurrence of gold, and in reference to the origin of the precious metal, he said: "I had long ago come to the conclusion, that most, if not all, the gold in the quartz reefs was derived from the rocks in which these reefs occur. That the strata themselves received their supply of gold at the period of their deposition from the ocean in which they were deposited. That organic matter, and the gases generated therefrom on decomposition, sulphuretted hydrogen, etc., was the cause of the precipitation, and that the amount of metallic deposit was in proportion to the amount of organic matter deposited with the oceanic

[1] On the Age of the N. S. Wales Coal-beds. By R. Daintree.—The Geologist, 1864, vol. vii. pp. 72–79.

[2] Report on the Geology of the District of Ballan, including Remarks on the Age and Origin of Gold. By R. Daintree. Vict. Geol. Survey Report, 1866, No. 15, pp. 11, folio. Melbourne.

*Maps.*—Sheet 8 S.E. (Tarneit); 8 S.W. (Mount Mary); Sheet 12 S.E. (Balliang); Sheet 19 N E. (Annakie Hills); 19 S.E. (Station Peak); 20 N.W. (You-Yangs); 20 S.W. (Rothwell); Sheet 23 N.W. (Point Wilson, etc.); Sheet 24 S.E. (Geelong); Sheet 28 N.E. (German Town); and Sheet 29 S.W. (Thompson's Creek). By R. Daintree and C. S. Wilkinson, etc.

sediment. The subsequent plication and desiccation of the sediment caused fissures, into which the mineral waters percolating, the boundary rocks flowed and were decomposed, and their mineral contents were precipitated, possibly by magnetic currents, thus causing mineral veins."

The geological and other scientific acquirements of Richard Daintree were not lost upon the Queensland Government, for in 1867 they requested him to make an examination of the Cape River district, which resulted in the opening up of the Cape River Gold-field.[1] In 1869 he was appointed Government Geologist for North Queensland, whilst the late Mr. C. D'Oyley H. Aplin was appointed to a similar post in the southern part of the same colony. The Queensland Government were able to secure the latter gentleman's services through the parsimony of the authorities of the Victorian Colony in breaking up one of the most complete Geological Surveys ever organized, except perhaps that of the United States Territories, under Dr. F. V. Hayden. During the three years intervening between 1869–71, Mr. Daintree examined large areas in North Queensland, including those of the Gilbert[2] and Etheridge Rivers, and the Ravenswood district, which have since proved highly auriferous and remunerative to those employed on them.

The importance of proper and efficient representation at the London Exhibition of 1872 was not lost upon the Queenslanders, for in 1871 Mr. Daintree was appointed Special Commissioner, and in consequence left the colony. The wisdom of the Colonial Government's selection cannot be better borne out than by the admirably organized and arranged Queensland Annexe of that and succeeding Exhibitions, in the administration of which Mr. Daintree took the entire superintendence and most active part, although latterly much broken in health. The office of Agent-General in London to the Colony of Queensland falling vacant at this time, the subject of our notice was appointed to it in March, 1872, a post held by him until 1876, when, in consequence of ill health, he was obliged to resign. It is gratifying to find that the services rendered by Mr. Daintree to the Colony in his official capacity, and to Colonial Science generally, were so far recognized by the Home Authorities, that it pleased Her Majesty, on his retirement, to confer on him the well-merited honour of C.M.G. It was hoped by his friends that rest and change would, to some extent at least, restore his shattered health, but notwithstanding a residence at Mentone during the winters of 1876 and 1877, and all that professional attention and affectionate family care could do, he gradually sank, and shortly after reaching this country in May last, he passed away. In a letter to a mutual friend dated Mentone, November, 1876, Daintree wrote thus:—"Thanks to hard work and rough food in a tropical climate, I managed to damage my liver, so

[1] Report on the Cape River Diggings and the Latest Mineral Discoveries in North Queensland. By R. Daintree. Folio, pp. 7, Map. Brisbane.

[2] Report on the Gold Discoveries in the Gilbert Ranges, with Sketch Map. By R. Daintree. Folio, Brisbane, 1869. Report on the Gilbert Ranges Goldfield, with Maps. By R. Daintree. Folio, Brisbane, 1869.

that I am now a martyr to chronic dyspepsia; and, thanks to sedentary employment in London, and the fog and damp of the English climate, I managed to get congestion of the lungs, with more or less hæmorrhage several times, so that, at an age when I ought to be availing myself of my accumulated experience in various ways, I find myself a confirmed invalid, cut off from all active enterprise whatever."

A large proportion of the valuable results of Daintree's work in Australia were nearly lost through the wreck of the ship (on board which he and his collections were stowed) at the Cape of Good Hope. Fortunately, however, the cases were recovered, and their contents supplied the material for the most exhaustive paper yet published [1] on Queensland Geology. One of the chief points there brought out was the great extent of ground occupied by rocks of Cretaceous age in the north of Australia, for although Cretaceous fossils had been determined some years before by Prof. M'Coy, Mr. Daintree appears to have been the first to point out the extent of the beds containing them. During the last few years of his life, when incapacitated by illness from active exertion, the microscope afforded Mr. Daintree much enjoyment, his attention being particularly directed to the subject of Petrology, more particularly as applied to Queensland rocks. We are informed that at the time of his death he had in preparation an important work on this subject.

An accomplished photographer, Mr. Daintree exhibited a fine series of Photographs at the Edinburgh Meeting of the British Association in 1871, and read a short paper [2] illustrated by them. His last scientific communication was read to the Geological Society of London on February 20 of this year.[3]

Richard Daintree was an enthusiastic man of science, and especially devoted himself to Geology, Chemistry, and Photography; a man of great determination and strength of character; methodical and practical in all his habits; a genial companion, a true friend, and a most conscientious servant of the Crown. He has unfortunately passed from amongst us at a time when, had he retained his health, his vast knowledge of Australian Geology would have been of inestimable value to Science, especially to that branch to which he had more particularly devoted himself, the origin and occurrence of Gold. His memory will long linger in the minds of his many close and intimate friends, and in none more than those who had the pleasure of his acquaintance during the active years of his life, and who shared with him some of the dangers and difficulties of "bush life," which have, we fear, in a great measure tended to shorten the career of one of the most accomplished of Australian Geologists.

R. E., Jun.

[1] Notes on the Geology of Queensland. By R. Daintree, F.G.S. With an Appendix, containing Descriptions of the Fossils, by R. Etheridge, F.R.S., and W. Carruthers, F.R.S. Quart. Journ. Geol. Soc. 1872, vol. xxviii. pp. 271–360, Maps and Plates, etc.

[2] On the General Geology of Queensland. Brit. Assoc. Report for 1871, pt. 2, p. 95.

[3] "Notes on Certain Modes of Occurrence of Gold in Australia."

Fig 1

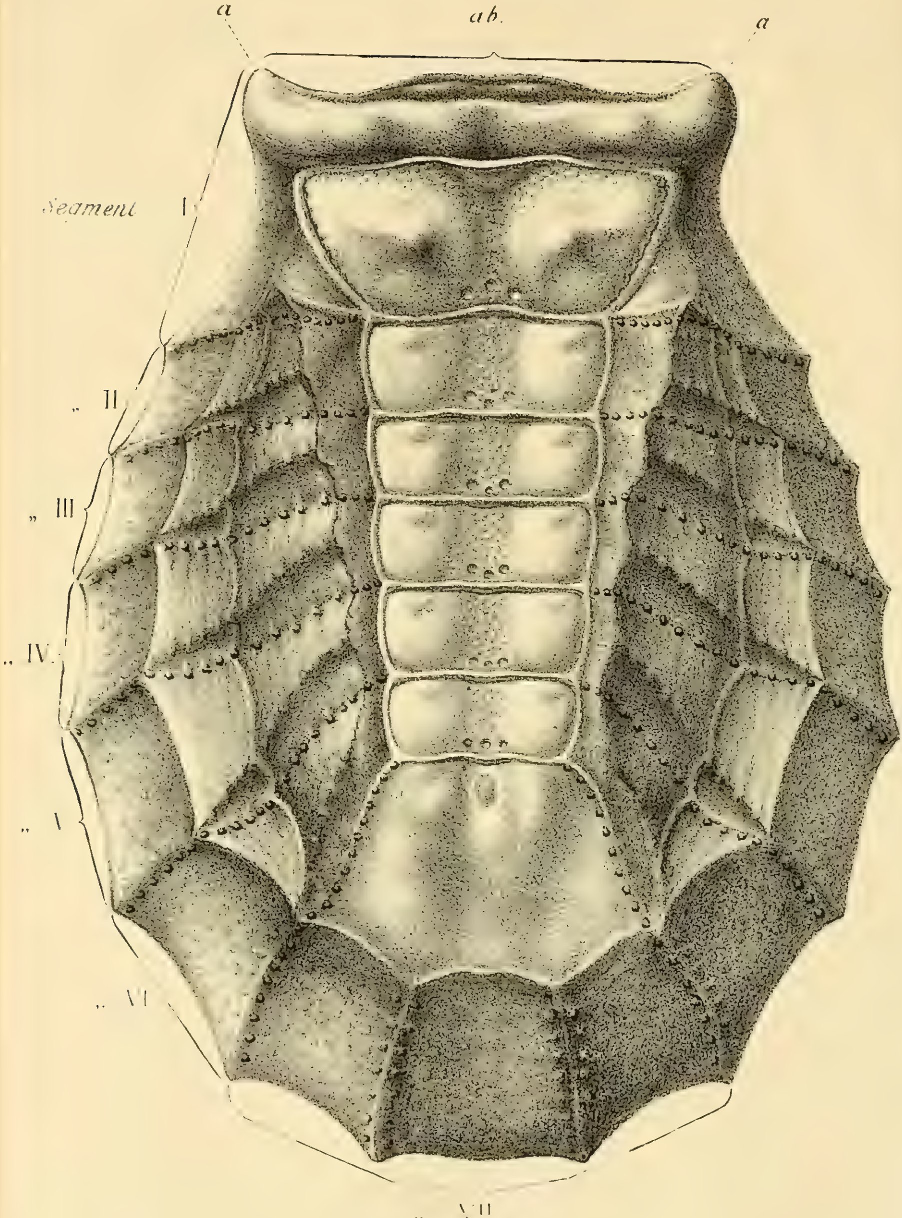


Fig 2

gr. nat.

*Brachypyge carbonis.* H. Woodward, 1878.

THE

# GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. V.

No. X.—OCTOBER, 1878.

## ORIGINAL ARTICLES.

### I.—Discovery of the Remains of a Fossil Crab (Decapoda-Brachyura) in the Coal-Measures of the Environs of Mons, Belgium.

By Henry Woodward, LL.D., F.R.S., F.G.S., etc., of the British Museum.

(PLATE XI.)

M. A. PREUDHOMME DE BORRE, the Conservator of the Royal Museum of Natural History in Brussels, having received, some time since, from M. Persenaire, the impression and counterpart of the abdomen of a small Crustacean discovered in the Coal-shales at the 'Belle-et-Bonne' Colliery, near Mons, he submitted it to the inspection of the Entomological Society of Brussels at their Monthly Meeting on 5th June, 1875.

After carefully examining these impressions, Professor L. G. de Koninck stated that in his opinion they certainly belonged to an entirely new genus and to a species of Crustacean not hitherto known from the Coal-measures. By his kindness, the fossil was afterwards transmitted to me for examination, and, at his request, I drew up the subjoined account of this very interesting and unique specimen, which has since been communicated by Professor de Koninck to the Royal Academy of Belgium.[1]

The Coal-measures have long been celebrated for the wonderful assemblage of organic remains which they have yielded, an assemblage none the less interesting from the fact that some of these remains represent groups of animals which belonged to the Palæozoic period, and whose last representatives are found in the Carboniferous formation, such as the genera *Phillipsia* and *Eurypterus;* while others, on the contrary, belong to the Neozoic period, and make their first appearance on this horizon.

Among these latter we may mention the first appearance of Amphibia; of Scorpions and Spiders; of Myriapods; of Orthoptera (Locustidæ, Mantidæ, Blattidæ); of Neuroptera; and the first Lobster-like Crustacean (*Anthrapalæmon*).

Other forms, characterizing at the same time the Palæozoic and the Neozoic periods, are equally well represented in the Carboniferous formation. Of these, the genera *Prestwichia* and *Bellinurus* may be

[1] See the Bulletins de l'Académie Royal de Belgique, 2me série, tome xlv. No. 4, Avril, 1878.

cited as examples. These Limuloid Crustaceans have their earliest representative (*Neolimulus*) in the Upper Silurian shales of Lanarkshire, whilst their latest representative (*Limulus*) is actually found living in the seas around China and Japan and on the East Coast of North America at the present day.

Professor L. G. de Koninck has just drawn my attention to a remarkable fossil obtained by M. Persenaire from the Coal-shales of the 'Belle-et-Bonne' Colliery, near Mons, Belgium.

This specimen, so kindly placed in my hands for examination by M. de Koninck, represents, without doubt, the abdomen of a female Crab (Decapoda-Brachyura). Unfortunately no other part of the animal has been discovered; we can only, therefore, conjecture what its general form may have been from a consideration of the portion preserved.

The specimen, which is 12 millimètres in length, is preserved upon the surface of a fragment of Coal-shale associated with the impressions of *Neuropteris heterophylla* and *Alethopteris lonchitidis.*

The abdomen is as nearly as possible perfect, and upon the surface of the two pieces of shale, which correspond, we see clearly the impression and counterpart of the fossil.

Notwithstanding the small size of the specimen, M. Rutot, C.E., has executed, under the direction of M. L. G. de Koninck, an admirable figure, greatly enlarged, showing clearly all the salient points of the fossil. By the kindness of the Council of the Royal Academy, I am enabled to reproduce this excellent figure (see Plate XI.).

As in other short-tailed Decapod-Crustacea, the abdomen is seen to consist of seven segments more or less completely ankylosed together, as in the Leucosiadæ. Unfortunately the external surface of the central axis of the abdomen is wanting, but the divisions, strongly indicated by raised lines, plainly show the area of each segment of the median portion of the abdomen, and also clearly separate the central axis from the widely expanded lateral border.

The general form of the abdomen is oval save at its proximal border, where it was attached to the cephalothorax (Pl. XI. Fig. 1, *a b*). This articular border (*a b*) measures 5 mm. in breadth, and was evidently inserted under the posterior margin of the carapace to about the depth of one millimètre.

The two angles of the articular margin (*a*, *a*) project slightly beyond the rest of the border, and evidently furnished two strong points of attachment with the abdomen.

The 1st segment, of which the articular border forms a part, is in the form of a trapezium, having its broadest border directed forwards and measuring 5 mm. in breadth, whereas the posterior border only measures 3½ mm.; the lateral borders of the segment are greatly inclined.

The central part of this segment bears two tubercles placed symmetrically, one on either side of the mesial line, whilst three small punctæ are placed near the centre of the posterior border.

The axial or central part of the 2nd, 3rd, 4th, 5th, and 6th segments are nearly the same in form, but they diminish insensibly from the 2nd to the 6th segment. From $3\frac{1}{4}$ mm. in breadth by $1\frac{1}{4}$ mm. in length, they gradually decrease to 2 mm. in breadth and 1 mm. in length. Each segment bears three punctæ disposed symmetrically near the centre and in close proximity to the posterior border, with the exception of the 7th, or terminal, segment, which is ornamented with a single small oval tubercle, situated on the median line and near the anterior border.

The 7th segment is three and a half times as long as the 6th, or preceding, segment; it spreads out in a fan-shaped form, being only 2 mm. broad at its anterior border, whilst it expands posteriorly to a breadth of 6 mm. at its lower extremity.

The lateral or epimeral border of the segments is about $3\frac{1}{2}$ mm. in breadth; its surface ornamentation has been preserved, and evidently once extended over the central axis also, but has been removed from this part of the specimen probably when separating it from its counterpart.

The divisions existing between each segment are clearly marked, and are continued to the lateral border of the abdomen in the form of a series of slightly raised lines, each marked by a row of small tubercles. The outer border of each segment is slightly concave or emarginated.

A raised line, having its origin at the side of the central axis of each abdominal segment, traverses the epimeral portion of the 2nd, 3rd, 4th, 5th, and 6th segments, forming a slightly sigmoidal curve, inclining downwards and uniting with the posterior margin of each segment near its border.

Two lines, nearly parallel, and corresponding in contour with the curvature of the exterior border of the abdomen, pass across the lateral portion of each segment between the 1st and the 7th, when they unite to form the limit of the central or axial part of the last segment; by these lines the lateral border of the abdomen is divided into three parts sloping fanwise towards the exterior.

With the aid of a magnifying glass the surface of the border of the abdomen is seen to be ornamented with fine granulations.

From the general conformation of the segments, and after careful comparison with numerous specimens, we are led to the conclusion that the fossil under consideration represents the abdomen of a female Brachyuran Decapod, and not the thoracico-abdominal segments of a Limuloid Crustacean such as *Bellinurus* or *Prestwichia*, with the form and segmentation of which it cannot be confounded. Nor are we acquainted with any Arachnide which presents a form of abdomen similar to this fossil. Nevertheless, in comparing this interesting specimen with the abdomen of numerous modern short-tailed Decapods, we cannot but observe that it presents many well-marked and distinctive peculiarities, both in the form of the segments themselves and also in their ornamentation.

Having lately received from Mr. J. McMurtrie several fragments of a new Crustacean discovered by him in the Radstock Coal-field, near Bristol, and also some other portions which I have reason to believe may have likewise belonged to a Brachyuran Decapod from the Pendleton Colliery, near Manchester, I have felt greater confidence in the determination of the Belgian fossil, and in considering it as constituting the abdomen of a true crab.

The most ancient short-tailed crab hitherto known is the *Palæinachus longipes* from the (Forest Marble) Great Oolite, Malmesbury, Wiltshire, which I described in 1866.[1]

The discovery of this fossil, therefore, removes the origin of the Decapoda-Brachyura to an epoch in geological time far anterior to that hitherto recorded, and serves to show well how little reliance can be placed upon merely negative evidence.

In the absence of other remains which might serve to complete our knowledge of the animal we have ventured to describe, it would be premature to attempt to show its affinities with any existing form or to give it a name indicative of its relationship. I prefer, therefore, to designate it as *Brachypyge carbonis*, for in the event of the discovery of more complete remains which would enable us satisfactorily to determine the modern representatives of this interesting species, the name (if calculated to mislead) would of necessity at once become a burden to synonymy.

### EXPLANATION OF PLATE XI.

*Brachypyge carbonis*, H. Woodw. From the Coal-measures, 'Belle-et-Bonne' Colliery, near Mons, Belgium.

Fig. 1.—Figure enlarged ten times. | Fig. 2.—Figure of the natural size.

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## II.—The Fossil Brachiopoda of the Lower Boulonnais.

THE following carefully and elaborately prepared list of the fossil Brachiopoda of the Lower Boulonnais has been forwarded to the Editor for publication by his esteemed friend and frequent contributor Thomas Davidson, Esq., F.R.S., who writes as follows:—

"At my request M. E. Rigaux (51, Grande Rue, Boulogne-sur-mer, France) has been engaged for more than two years in drawing up a complete summary of all the Brachiopoda that are to be found in the various formations composing the Lower Boulonnais.

"This list is of great importance as so many of the beds correspond completely with our own, and are extremely rich in a palæontological point of view. Thomas Davidson.

"3, Leopold Road, Brighton, 7*th August*, 1878."

### List of Fossil Brachiopoda found in the Lower Boulonnais.

By Monsieur E. Rigaux.

#### Devonian.

*Terebratula sacculus*, Mart. Very common in the shales of Beaulieu, scarce in the Ferques limestone.

*Spirigera concentrica*, D'Orb. Very common in the highest beds of the Ferques limestone; Blacourt, Beaulieu.

*Spirigera Pelapayensis*, D'Orb. Rather common in the shaly beds over the Blacourt limestone in the Cédule quarry, scarcer in the Ferques limestone at Blacourt.

[1] Quart. Journ. Geol. Soc. vol. xxii. p. 494.

*Spirigera Davidsoni*, R. Is found only in the shales over the Blacourt limestone at Couderousse.

*Spirifer Verneuilli*, Murch. Very common in all the Devonian shales and limestones, offers several varieties; in the limestones the wings are short, and the beak strongly incurved; in the shaly beds the wings are very long, the area wide, and the beak not recurved; the variety *Archiachi* is found only in the higher beds of the Ferques limestone.

*Spirifer Bouchardi*, Murch. This species is found under varying forms at three levels; in the shales of the Cédule quarry it is depressed, larger, and the two ribs that limit the sinus are not so strong as in the second variety which is common at Couderousse; the typical form figured by Murchison is only found in a particular bed of the Ferques limestone.

*Spirifer Urii*, Dav. Scarce, Beaulieu shales.

*Spirifer Sauvagei*, R. Scarce; is found in the Beaulieu shales with the two following species in the level of *Strept. elegans*.

*Spirifer Legayi*, R. Common at Beaulieu.

*Spirifer Barroisi*, n. sp. Scarce, Beaulieu. This species is very near to *Sp. Legayi*, from which it differs by a less transverse form, a narrower sinus, laminæ of growth not so strong, but closer and more numerous.

*Spirifer undiferus*, Schn. Very scarce, Beaulieu.

*Cyrtina heteroclyta*, Dav. Rather common at the lowest part of the Beaulieu shales, does not seem to go higher than the level of *Strept. Bouchardi*.

*Cyrtina Demarlii*, Dav. Scarce, Beaulieu shales.

*Spirigerina reticularis*, D'Orb. This is a very common species, and offers several varieties; Ferques, Blacourt, Beaulieu.

*Spirigerina aspera*, M'Coy. Common, Ferques.

*Spirigerina longispina*, Bouch. Is only found in the sandy limestone band over the Ferques limestone.

*Rhynchonella Lummatoniensis*, Dav. Occurs in the Beaulieu shales.

*Rhynchonella acuminata*, Mart. A variety of this species is very abundant in the shales with *Strept. elegans;* Beaulieu.

*Rhynchonella Boloniensis*, D'Orb. Common in the upper part of the Ferques limestone, and in the sandy limestone over it; Beaulieu.

*Pentamerus brevirostris*, Phil. Is found commonly in a small calcareous band below the Ferques limestone.

*Orthis striatula*, D'Orb. Common everywhere, Ferques, Beaulieu.

*Orthis Deshayesii*, Bouch. Very common in the level of *Strept. Bouchardi*.

*Orthis Dumontiana*, Vern. Common in the same bed.

*Orthis Eifeliensis*, Sch. Scarce, is found with *Pent. brevirostris* at Beaulieu.

*Streptorhynchus Devonicus*, Dav. Common at the highest part of the Ferques limestone.

*Streptorhynchus elegans*, Bouch. Very common, distinguishes a particular level in the Beaulieu shales.

*Streptorhynchus Bouchardi*, R. Very common, Beaulieu shales.

*Strophomena latissima*, Bouch. Very common in the sandy band over the Ferques limestone.

*Strophomena Gosseletii*, R. Rather scarce, Beaulieu shales.

*Leptæna Dutertrii*, Murch. Very common in the highest part of the Ferques limestone.

*Leptæna Ferquensis*, R. Very common, Beaulieu shales.

*Leptæna Cedulæ*, R. Very common, lowest part of the Beaulieu shales.

*Leptæna Fischeri*, Vern. Common, Beaulieu shales.

*Chonetes armata*, Bouch. Very common over the Ferques limestone.

*Strophalosia productoides*, King. Very scarce, Ferques, Beaulieu.

*Productus subaculeatus*, Murch. Common in every bed, Ferques.

### Carboniferous Limestone.

*Terebratula hastata*, Sow. This species is found in great numbers in a bed from the highest part of the white limestone, Napoleon quarry.

*Athyris Roissyi*, M'Coy. This species has been found by Mr. Dutertre at Hardinghem in the Black quarry, which is now full of water.

*Spirifer laminosus*, M'Coy. Occurs sparingly in the white limestone at Hydrequent.

*Spirifer glaber*, Mart. Very common in the bed with *T. hastata.*

*Productus Cora*, D'Orb. This species is found in the lower limestone of the La Côte and Malassise quarries; it is more common in the Haut-banc limestone.

*Productus semireticulatus*, Mart. Common in the bed with *Tr. hastata*, was also formerly found in the Black quarry.

*Productus giganteus*, Mart. There occur in a small quarry near Ferques, and in another near Hardinghem, crushed specimens of a large *Productus* which Mr. Gosselet refers to this species.

### Bathonian.

*Terebratula maxillata*, Sow. This species occurs sparingly in the Great Oolite at Hydrequent and in the Cornbrash, Le Wast.

*Terebratula submaxillata*, Dav. This species is confined within the lower beds of the Great Oolite; Hydrequent.

*Terebratula globata*, Sow. Very common in the lower part of the Great Oolite at Hydrequent, is found also in the Marquise Oolite; the variety *Fleischeri*, Opp., occurs unfrequently in the Cornbrash at Le Wast.

*Terebratula intermedia*, Sow. Very common in the Cornbrash; Le Wast, Lenlinghem.

*Terebratula coarctata*, Park. Very scarce, Cornbrash, Le Wast.

*Terebratula hemisphærica*, Sow. I have found a single specimen in the Cornbrash; Le Wast.

*Waldheimia obovata*, Sow. Very common; the variety *Siddingtonensis* in the Great Oolite at Hydrequent; the varieties *perobovata, subobovata* and *Stiltonensis* in the Cornbrash at Le Wast.

*Waldheimia lagenalis*, Schl. Common in the Cornbrash with the variety *sublagenalis.*

*Waldheimia cardium*, Lam. Very scarce, Cornbrash; Le Wast, Lenlinghem.

*Rhynchonella concinna*, Sow. Common in the Hydrequent limestone.

*Rhynchonella Hopkinsi*, M'Coy. Very common in the Great Oolite of Marquise; a single specimen from the Cornbrash at Le Wast.

*Rhynchonella elegantula*, Bouch. Very common in the marly limestone between the Cornbrash and Great Oolite; Le Wast, Marquise.

*Rhynchonella Badensis*, Opp. Very common in the Cornbrash, Le Wast; a single specimen from Hydrequent, in the lower part of the Great Oolite.

*Rhynchonella Morieri*, Dav. Very common in the Cornbrash; Le Wast, Marquise.

*Rhynchonella varians*, Sow. var. We find in the Cornbrash at Rinxent a small form which we refer to this species.

Oxford Clay and Lower Calc Grit.

*Waldheimia umbonella*, Lam. Very common at Belle; a single specimen from the clays at Le Wast.

*Rhynchonella socialis*, Phill.

*Rhynchonella Leedsii*, Walk. These three species are found in the ferruginous Oolite (Kelloway Rock), over the Cornbrash at Belle and Alincthun.

*Waldheimia impressa*, Buch. Occurs in great numbers in the clays at Le Wast; one specimen has been found in the Coral Rag at Carly.

*Terebratula insignis*, Sow. Scarce in the Calcaire and Houllefort (Elsworth rock); it is more common in the calcareous band over it at Rety, and is very abundant in the Calcaire du Mont des Boucards.

*Waldheimia bucculenta*, Sow. Very scarce, I have found six specimens in the Calcaire du Mont des Boucards.

*Rhynchonella pectunculoides*, Et. Very common in the lowest beds of the Calcaire du Mont des Boucards.

*Rhynchonella myriacantha*, Desl. I have found a single specimen in the clays at Blèquenèque.

*Rhynchonella spathica*, Lam. Very common in the *Ter. impressa* beds; Le Wast.

Coralline and Supracoralline Beds.

*Terebratula insignis*, Sch. Ends in the Supracoralline Oolite at Hesdin l'Abbé with forms which show a transition between this species and *T. subsella*.

*Terebratula subsella*, Leym. Shows itself at first in the Supracoralline Oolite at Hesdin l'Abbé, and goes up in the Kimmeridge beds.

*Terebratula globata*? Sow. The Oolite of Hesdin l'Abbé contains a biplicated *Terebratula*, which I cannot distinguish from our Great Oolite *globata*.

*Waldheimia humeralis*, Röm. I have sometimes quoted this species under the name of *T. bucculenta*, which I apply now to another species at a lower level; it appears in the Coral Rag proper at

Carly, but is more abundant in the Supracoralline Oolite of Hesdin l'Abbé.

*Rhynchonella pectunculoides*, Et. This species goes up into the Coral Rag; Carly.

*Rhynchonella pinguis*, Röm. This species is found in the Coral Rag, Carly, and in the Supracoralline Oolite; Hesdin l'Abbé.

*Rhynchonella inconstans*, Sow. Very scarce, I have found it only in the Grès de Questrecques, the highest Supracoralline bed.

*Thecidium ornatum*, Moore. Mr. Davidson first found this species on a *Ter. humeralis* from the Carly Coral Rag, and since I have obtained some other specimens, but it is rather scarce.

### Kimmeridge Clay.

*Lingula ovalis*, Sow. This species was discovered by Mr. J. E. H. Peyton, F.G.S., near the base of the shales in the cliffs of Boulogne;[1] it is very common. I have also found in the Portland shales remains of a *Lingula* which belong probably to the same species.

*Terebratula subsella*, Leym. Is rather common in the lower part of the Kimmeridge. Cliffs of Moulin Wibert, Chatillon.

*Waldheimia humeralis*, Röm. I refer with doubt to this species, some small smooth *Terebratulæ* found by Mr. Beaugrand in the Lower Kimmeridge beds; Moulin Wibert.

*Rhynchonella pinguis*, Röm. Very scarce; two or three specimens have been found in the lowest beds in the cliff of Moulin Wibert.

### Portlandian.

*Discina latissima*, Sow. I have found good specimens of this species in the shales that overlie the grits with *A. gigas* in the cliffs at La Crèche and Le Portel; it is rather common.

*Waldheimia Boloniensis*, R. S.

*Waldheimia humeralis*, Röm.

*Rhynchonella subvariabilis*, Dav. These three very scarce species are found in the Middle Portland beds with *Ostrea expansa*; Tour Croy, Alpreck.

### Lower Greensand.

*Waldheimia pseudojurensis*, Leym.

*Rhynchonella Gibbsiana*, Sow. These two very scarce species have been found by Mr. Bouchard in the sands under the Gault with *Amm. mammillaris*; Locquinghem.

### Gault.

*Terebratula prælonga*, Sow. Occurs in the phosphatic bed under the Gault; Fiennes, Lottinghem.

*Rhynchonella Gibbsiana*, Sow. In phosphatic nodules, Fiennes.

*Rhynchonella lineolata*, Phill. I have some internal casts from Fiennes which seem to belong to this species.

### Chalk Marl.

*Magas Geinitzii*, Schl. This species has been found by Mr. Barrois at Licques and at Blanez.

[1] See Geol. Mag., 1873, Vol. X. p. 574, with a woodcut figure.

*Terebratella truncata*, Sow. We refer to this species some small specimens which occur rarely in the Cement Chalk at Neufchatel, but Mr. Barrois looks upon them as belonging to a new species.

*Kingena lima*, Dav.

*Terebratulina striata*, Wahl.

*Terebratulina rigida*, Sow.

| Palæozoic Brachiopoda found in the Lower Boulonnais. | Devonian. | | | | | | | Carboniferous. | |
|---|---|---|---|---|---|---|---|---|---|
| | Blacourt Limestone. | Beaulieu Shales. | | | | Ferques Limestone. | Sandy Limestone. | Lower Limestone. | Upper Limestone. |
| | | *Spirig. Davidsoni* Shales. | *Strept. Bouchardi* Clay. | *Strept. elegans* Marl. | *Pent. brevirostris* Limestone. | | | | |
| *Terebratula sacculus*, Mart. | | | | x | x | | | | |
| *hastata*, Sow. | | | | | | | | | x |
| *Spirigera concentrica*, D'Orb. | | | | | | x | x | | |
| *Pelapayensis*, D'Orb. | x | | | | | x | | | |
| *Davidsoni*, R. | | x | | | | | | | |
| *Roissyi*, D'Orb. | | | | | | | | | x |
| *Spirifer Verneuilli*, Murch. | x | | | x | x | x | x | | |
| *Bouchardi*, Murch. | x | x | x | | | x | | | |
| *Urii*, Dav. | | x | x | | | | | | |
| *Legayi*, R. | | | | x | | | | | |
| *Sauvagei*, *R.* | | | | x | | | | | |
| *Barroisi*, n. sp. | | | | x | | | | | |
| *undiferus*, Sch. | | | | | x | | | | |
| *laminosus*, M'Coy | | | | | | | | | x |
| *glaber*, Mart. | | | | | | | | | x |
| *Cyrtina heteroclita*, Dav. | x | x | x | | | | | | |
| *Demarlii*, Bouch. | | | | x | | | | | |
| *Spirigerina reticularis*, D'Orb. | | | | | x | x | | | |
| *longispina*, Bouch. | | | | | | | x | | |
| *aspera*, M'Coy | | | | | | x | | | |
| *Rhynchonella Lummatoniensis*, Dav. | | | x | | | | | | |
| *acuminata*, Mart. | | | | x | x | | | | |
| *Boloniensis*, D'Orb. | | | | | | x | x | | |
| *Pentamerus brevirostris*, Phil. | | | | | x | | | | |
| *Orthis striatula*, D'Orb. | x | x | | x | x | x | x | | |
| *Deshayesii*, R. | | | x | | | | | | |
| *Dumontiana*, Vern. | | | x | | | | | | |
| *Eifeliensis*, Sch. | | | | | x | | | | |
| *Streptorhynchus Devonicus*, Dav. | | | | | | x | | | |
| *elegans*, Bouch. | | | | x | | | | | |
| *Bouchardi*, R. | | | x | | | | | | |
| *Strophomena latissima*, Bouch. | | | | | | | x | | |
| *Gosseletii*, R. | | | x | | | | | | |
| *Leptæna Dutertrii*, Murch. | | | | | | x | x | | |
| *Ferquensis*, R. | | | x | | | | | | |
| *Cedulæ*, R. | x | | | | | | | | |
| *Fischeri*, Vern. | | | x | | | | | | |
| *Productus subaculeatus*, Murch. | x | x | x | x | x | x | | | |
| *Cora*, D'Orb. | | | | | | | | x | x |
| *semireticulatus*, Mart. | | | | | | | | | x |
| *giganteus* | | | | | | | | | x |
| *Strophalosia productoides*, King | | | | | x | x | | | |
| *Chonetes armata*, Bouch. | | | | | | x | | | |

| Distribution of Oolitic Brachiopoda in the Lower Boulonnais. | Lower Great Oolite. | Upper Great Oolite. | Cornbrash. | Kelloway Rock. | Oxford Clay. | Lower Grit. | Coralline Limestone. | Supracoralline. | Kimmeridge Clay. | Portlandian. |
|---|---|---|---|---|---|---|---|---|---|---|
| *Lingula ovalis*, Sow. | | | | | | | | | x | |
| *Discina latissima*, Sow. | | | | | | | | | | x |
| *Thecidium ornatum*, Moore | | | | | | | x | | | |
| *Terebratula maxillata*, Sow. | x | | x | | | | | | | |
| *submaxillata*, Dav. | x | | | | | | | | | |
| *intermedia*, Sow. | | | x | | | | | | | |
| *insignis*, Sch. | | | | | | x | | x | | |
| *globata*, Sow. | x | x | x | | | | | x | | |
| *hemispherica*, Sow. | | | x | | | | | | | |
| *coarctata*, Park. | | | x | | | | | | | |
| *subsella*, Sow. | | | | | | | | x | x | |
| *Boloniensis*, R. S. | | | | | | | | | | x |
| *Waldheimia lagenalis*, Sch. | | | x | | | | | | | |
| *umbonella*, Lam. | | | | x | x | | | | | |
| *obovata*, Sow. | x | | x | | | | | | | |
| *bucculenta*, Sow. | | | | | | x | | | | |
| *impressa*, Buch. | | | | | x | | | | | |
| *humeralis*, Röm. | | | | | | | x | x | x | x |
| *cardium*, Lam. | | | x | | | | | | | |
| *Rhynchonella concinna*, Sow. | x | | | | | | | | | |
| *Hopkinsi*, M'Coy | | x | | | | | | | | |
| *elegantula*, Bouch. | | | x | | | | | | | |
| *Badensis*, Oph. | | | x | | | | | | | |
| *Morieri*, Dav. | | | x | | | | | | | |
| *varians*, (var.) | | | x | | | | | | | |
| *Leedsii*, Walk. | | | | x | | | | | | |
| *socialis*, Phil. | | | | x | | | | | | |
| *spathica*, Lam. | | | | | x | | | | | |
| *myriacantha*, Desl. | | | | | x | | | | | |
| *pectunculoides*, Et. | | | | | | x | x | | | |
| *pinguis*, Röm. | | | | | | | x | x | x | |
| *inconstans*, Sow. | | | | | | | | x | | |
| *subvariabilis*, Dav. | | | | | | | | | | x |

| Distribution of Cretaceous Brachiopoda in the Lower Boulonnais. | Lower Greensand. | Gault. | Upper Greensand. | Chalk Marl. |
|---|---|---|---|---|
| *Magas Geinitzii*, Schl. | | | | x |
| *Terebratella truncata*, Sow. | | | | x |
| *Kingena lima*, Dav. | | | | x |
| *Terebratulina striata*, Wahl. | | | | x |
| *rigida*, Sow. | | | | x |
| *Terebratula biplicata*, Sow. | | | x | |
| *prælonga*, Sow. | | x | | |
| *semiglobosa*, Sow. | | | | x |
| *squamosa*, Mant. | | | | x |
| *sulcifera*, Mor. | | | | x |
| *Waldheimia pseudojurensis*, Leym. | x | | | |
| *Rhynchonella Gibbsiana*, Sow. | x | x | | |
| *lineolata*, Phill. | | x | | |
| *Martini*, Mant. | | | | x |
| *Grasiana*, D'Orb. | | | | x |
| *Mantelliana*, Sow. | | | | x |

*Terebratula squammosa,* Mant. These four species are very common in the Chalk Marl at Blanez and Neufchatel.

*Terebratula biplicata,* Sow. Occurs in the Glauconitic bed above the Gault; Blanez.

*Terebratula sulcifera,* Morris. Seems to be very scarce; I know only two specimens which Prof. Gosselet has had the kindness to send me; Blanez.

*Terebratula semiglobosa,* Sow.

*Rhynchonella Martini,* Mant.

*Rhynchonella Grasiana,* D'Orb.

*Rhynchonella Mantelliana,* Sow. These four species are very common in the Chalk Marl at Blanez and Neufchatel.

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## III.—Supplementary Note to "Pleistocene Mammals Dredged off the Eastern Coast."[1]

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

(PLATE XII.)

THE late Dr. Falconer figured in the "Fauna Antiqua Sivalensis," a fine lower jaw of an adult *Elephas primigenius,* preserved in the National Collection, and of which he gives two views, the first as seen from above, the second a side view; and in the descriptions of the plates in the above work given in his "Palæontological Memoirs," vol. i. p. 439, occurs the following note regarding it: "Plate xiii. A. fig. 3.—*E. primigenius.* English fossil specimen, with two last true molars on either side. In the last left molar there are eighteen plates in 7·7 inches. The jaw has a short beak, and one inner mentary foramen on either side. In this, as in figs. 1 and 2, representing the jaw at different ages, it is to be noted that the opposite lines of molars are more or less convergent instead of being parallel, or nearly so, as laid down by Cuvier.

"Extreme length of jaw, 23·6 in. Divergence of rami behind, 21·3 in. Height at alveolus, 7·2 in. Greatest width of jaw, 6·3 in. Breadth of condyle, 10·3 in., width of last molar, 2·8 in."

To the above description may be added, that although the ascending rami are well preserved, the condyles and coronoids on each side are wanting.

Besides the fact that it is a dredged specimen, which is evident from the marine exuviæ still adhering to it, and that Dr. Falconer had selected it for illustration as a type of the mandible of a mature adult animal of the above species, not anything was known respecting its history, or whence it came, by the present officials of the Palæontological Department; nor beyond the statement that it is an "English fossil specimen" does Dr. Falconer throw any light upon its history, if he ever knew it. But some time ago, looking through a volume of the "Magazine of Natural History," edited by Mr. Edward Charlesworth, F.G.S., I found a woodcut of the fossil, and a short notice regarding it by the editor, both of which we here reproduce.

"The fossil elephant's jaw represented in the accompanying figure

[1] See Geol. Mag., 1878, Decade II. Vol. V. p. 97.

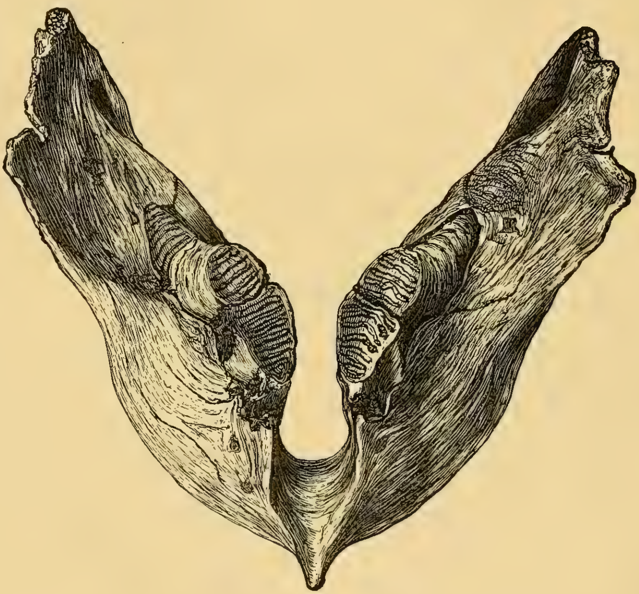
(No. 40), was obtained by a Dover fisherman in 1837, while dredging off the Dogger Bank; and after having been offered for sale to the British Museum and other Metropolitan institutions, was purchased by Mr. G. B. Sowerby, in whose possession it has since remained. It is decidedly the finest relic of the kind that I have seen; and the very faithful representation which I am enabled to publish of it is due to the skill of Mr. G. B. Sowerby, jun., by whom the drawing on wood was executed."[1]—Mag. of Nat. Hist. July, 1839, vol. iii. pp. 347–8. However, the specimen was ultimately purchased for the National Collection on the recommendation of Mr. C. Kœnig, the then Keeper of the Geological Department, soon after the publication of Mr. Charlesworth's notice.

The special interest attached to the jaw, apart from its importance as having been selected as a type specimen by so acute an observer as Dr. Falconer, is the locality whence it has been derived, and the additional confirmation it gives of the typical character of the remains of the Mammoth obtained from the Dogger Bank, as described by me in a notice of the almost unique collection from this locality made by Mr. J. J. Owles, of Yarmouth, in the March Number of the present volume of the GEOLOGICAL MAGAZINE (p. 97). Thus it appears, on the evidence before us, that *Elephas primigenius* is the only species found on the Dogger Bank, whereas the three species *E. primigenius*, *E. antiquus*, and *E. meridionalis*, all occur in the Forest-bed series along the Norfolk coast. Of these the *Elephas antiquus*, according to Dr. Falconer, would seem to be the most abundant, for he says: "Of the two thousand Elephant grinders, which Mr. (Samuel) Woodward estimates to have been dredged up within thirteen years, from the oyster-bed near Happisburgh, I believe that by far the largest number belonged to this species. The next in point of number, are those of the true Mammoth from the wide-spread drift and gravel-beds. Teeth of *E. meridionalis* are much less frequent."—("Falconer's Palæontological Memoirs," vol. ii. p. 204.)

Considering the interest attached to this locality, and the number of fossils it has yielded to the dredge, the records regarding them are few. Prof. Owen, in his "British Fossil Mammals," has given a most extensive summary, both of the remains found, and the localities whence fossil elephants have been obtained, but has no notice of this jaw, unless the following quotation refers to it: "A fine lower jaw of a young Mammoth, in the possession of Mr. G. B. Sowerby, was thus dredged up off the Dogger Bank; and a femur and portion of a large tusk were raised from twenty-five fathoms at low water, midway between Yarmouth and the Dutch coast."[2] But when the above was published, the mandible noticed by Charlesworth had been long in the British Museum, and his engraving of it had been known for some years.

[1] Mr. Charlesworth subsequently used the woodcut to illustrate the wrapper of his "London Geological Journal." The accompanying figure, Plate XII., is a careful reproduction of the original by Miss G. M. Woodward.

[2] Brit. Foss. Mamm. and Birds, 1846, p. 259.



Lower Jaw of Mammoth,

*Elephas primigenius*, Blum.

Dredged off the Dogger Bank, 1837.

*The Original preserved in the British Museum.*

*G. M. Woodward, delt.* *S. Austin and Sons, imp.*

## IV.—On the Ancient Volcanic District of Slieve Gullion.[1]

By Joseph Nolan, M.R.I.A., etc.,
of H. M. Geological Survey of Ireland.

It seems to be one of the chief objects of the British Association for the Advancement of Science in changing the place of meeting every year, to bring more prominently before the members of its respective sections such points of interest in their own department of Science as are afforded by the various localities. In accordance with this principle, I beg to lay before you some observations concerning the geology of a district not more distant than about two hours' railway journey from Dublin, which will, I trust, be of peculiar interest on the present occasion. The district I refer to is the hill country north of Dundalk, of which Slieve Gullion forms the most prominent feature. This mountain is a somewhat isolated mass, attaining an elevation of about 1900 feet, and is situated to the north-west of the hilly and picturesque country lying between the bays of Dundalk and Carlingford, or due west of the more remarkable group of the Mourne Mountains. The rocks of which it is mainly composed are of a plutonic character, and rise through granite, the south-western termination of the tract of that rock which extends from this in a north-easterly direction to Slieve Croob, a distance of about thirty miles. This granite is not in the main intrusive, but is rather the result of the metamorphism of the Lower Silurian sedimentary rocks. The transitions from the latter into the former may be observed in many places—the Silurian rocks becoming indurated, then schistose and slightly micacised, passing into crystalline gneiss, which frequently loses its foliation and passes into granite. In other places the transitions are somewhat less gradual, chemical differences in the composition of the rocks having probably favoured the readier conversion into granite, while in others again, no transition whatever is perceptible, and the rock seems in those parts to be intrusive, the more highly fused portions having been forced up and thrust through the upper parts of the sedimentary rocks, or those least affected by metamorphosing agencies. A remarkable instance of the kind may be seen at Mullaghbane, some four miles west of Slieve Gullion, where a tongue from the granite cuts through both the Silurian sedimentary rocks and an old igneous rock (diorite) associated with them; while in the same neighbourhood, transitions from the indurated sedimentary rocks into the main mass of the granite are exceedingly well marked, and even hand specimens exhibiting these changes may be procured.

Similar phenomena were also noticed on the eastern side of the mountain, of which my colleague, Mr. Egan, gives many instances. (See Geological Survey Explanation to accompany Sheet 59). Thus, at Camlough Mountain, he observes that, "the granite contains

[1] Read before the British Association for the Advancement of Science, Dublin, (Section C.), August 15, 1878.

gneissose bands merging into harder and more solid granite," and in the hill east of this mountain, where the granite is similar, though in places nearly losing its mica, there is an unmistakable passage from micaceous schists into foliated granite" (*ibid.* p. 14).

The age of formation of this, called the Newry granite, cannot be determined, but there is strong reason for believing that it took place prior to the Upper Silurian period, as suggested by Prof. Hull.[1] The basal conglomerates of that system contain pebbles and boulders of granite, as well as of schist and gneiss, and as granite fragments are not met with, in Ireland at least, in formations older than the Lower Silurian, we may fairly assume that it was formed with the schist and gneiss, the eruptive and metamorphic granites being but varied results of the same plutonic action.

*Micaceous Dolerite.*—Eruptive through the granite is a coarsely crystalline rock of massive character, forming most of the northern and western parts of the mountain. It has the usual characteristic appearances of dolerite, having a rude prismatic structure and weathering in globular exfoliating masses. It consists of augite and plagioclase felspar, of which there may be more than one variety, those most largely developed being labradorite. In addition, it has a bronze to black-coloured mica, sometimes in considerable quantity, a large proportion of magnetite, olivine, and a green structureless mineral that is probably epidote.

*Elvanite or quartz porphyry.*—Associated with this dolerite, and forming the remaining part of the mountain, is a granitoid rock consisting chiefly of orthoclase felspar with free silica, seldom developed into well-formed crystals, a little mica, and, usually, some hornblende. This rock is seen in many places to penetrate the micaceous dolerite, and is therefore probably older, though as the dolerite also, though rarely, sends veins into the elvanite, it is most likely that both were protruded about the same time. To the north-west, this elvanite composes the remarkable ridge of hills that partly inclose the mountain on the north, west, and south. At half the extent of its course, at Cashel Lough, it changes gradually from a granitoidal rock to one having a finer grained or compact base, and containing double pyramidal crystals of quartz with felspar, thus becoming a highly silicated or quartzose felstone porphyry.

*Volcanic Agglomerate.*—Simultaneously with this change in the elvanite, suggesting conditions of less intense heat and pressure, a fragmental rock of most remarkable character makes its appearance. It is here entirely composed of granite pieces, and might indeed be taken for a disintegrating portion of that rock, but that, on examination, the base is found to present a mechanical and not a crystalline structure. This conclusion is confirmed on following the ridge farther south, where, in the neighbourhood of Forkill, the associated fragmental rock occupies a large area, and though still mainly composed of granite, yet contains several fragments of other rocks, all of which, however, are of local origin. Eastward of Forkill,

[1] See Physical Geology and Geography of Ireland, p. 141, note.

patches of it are found in many places over the igneous rock, but slate fragments are here prevalent, till, at the termination of the ridge, at Slievenabolea, they almost form the entire mass, like the granite at the other end, the lower portions, however, passing into the felstone by such insensible gradation that no line of demarcation is possible.

That this rock is of a volcanic character, somewhat analogous to volcanic agglomerate, we can scarcely entertain a doubt. Nevertheless, it differs widely from the usual type of that rock, as it is, except in the deepest portions, almost altogether composed of pieces of non-volcanic rocks, these fragments being the pre-existing crust through which the igneous mass was protruded, and varying accordingly—granitic agglomerate prevailing in those portions that were occupied by that rock—a mixture of slate and granite about the junction of these formations, and slate fragments almost exclusively in the Silurian district to the south-east. It is impossible to account for these phenomena by supposing that we have here the result of an eruption of an ordinary character where lava or scoriæ is ejected, as, if that were the case, some fragments at least of these products would occur in the agglomerate, if, indeed, as usually happens, they did not compose the entire mass. Lava or scoriæ, therefore, could not have been ejected, and the eruption must have been entirely of an aëriform character. The theory which Professor Judd proposes to account for the formation of vast craters, such as those of the lakes Bolsena and Bracciano in Central Italy, seems to afford a probable explanation of the facts in this case. Where the igneous mass rises through a vertical fissure, the initial eruptions, due to a mere "local disengagement of vapour," are, comparatively speaking, moderate in their effects, and followed by others sometimes lasting for lengthened periods, as fresh accessions of lava, charged with elastic gases, are continually welling upward, owing to diminished pressure; but when, as in the case of intrusive sheets, the lava is projected in a horizontal or nearly horizontal fissure from the volcanic focus, there is a tension exerted on the overlying rocks through a far larger area, which being at length overcome, produces a tremendous and widespread explosion, but of a very temporary character, there being no deep portions to furnish fresh supplies. That in the district now described, eruptive rock was projected in some such manner seems highly probable, both from its position, as a dyke-like protrusion from the igneous mass of Slieve Gullion, and the disposition of the agglomerate. This latter is associated with it for seven miles of its course, its volcanic character being most evident at the eastern end of the huge dyke, where we may suppose it approached somewhat nearer the surface of the ground, while about Cashel Lough, close to where it disappears, it is scarcely distinguishable from the adjacent granite, the intumescent mass having been here more deeply seated, and in consequence no further result produced than a fissuring and partial dislocation of the overlying crust.

While, therefore, the elastic forces appear to have been sufficient to produce aëriform explosions and the shattering and trituration of the superincumbent rocks, they do not appear to have been powerful enough to raise the igneous mass sufficiently near the surface to produce lava or scoriæ. This was probably due to the operation of two causes, one of which I have already referred to—the sudden consolidation of the crystalline magma on losing its interstitial fluids—the other, and perhaps principal cause, the immense weight and volume of the displaced materials. To this latter cause Mr. Scrope refers the formation of fragmental rocks in the Upper Eifel, very similar to those just described. These, he informs us, are "principally, and in some instances almost entirely, composed of broken greywacké slate and sandstone, more or less affected by heat, and pulverized. . . . There is an appearance as if the volcanic energy had been damped and impeded by the mass of transition and secondary strata which it had to pierce, and perhaps by the fragile nature of the greywacké slate, which, shattered and pulverized by the first few aëriform explosions of every eruption, would be likely to accumulate in great volume above and within the vent, and stifle its further activity."—(*Volcanos*, p. 376, *et seq.*)

Besides the felspathic rock mainly associated with the agglomerate, there are others of a basic character, chiefly dolerites and melaphyres. These usually occur as bosses and protrusions through the felspathic rocks, and are generally tuffose at the surface, graduating imperceptibly into the agglomerate. One of the most remarkable of them is to be seen at Glendooey, west of Carrickbroad, where it rises as an abrupt dark mass on the side of the hill, and, crowned with an ornamental turret, forms a very pretty and conspicuous object. It has all the appearance of a volcanic vent, and the tract of dark basic rock, which spreads to the southward, probably proceeded from it. This latter has been microscopically examined by Professor Hull, who finds it to be composed of triclinic felspar and epidote, the latter, however, occurring as a secondary mineral, and not improbably having replaced augite. (See Geol. Survey Explanation to accompany Sheet 70, p. 19.)

Although at first it might appear that these basic rocks are newer than the felstone porphyry, yet there is good reason for believing that they were formed about the same time, that is, during the continuance of the same volcanic action. Their graduating into the agglomerate is a very good reason why we should consider them coeval with it, and their protrusion through the porphyry is probably more due to the great differences in the respective fusibilities of these rocks than to later eruptions. Thus, Prof. Jukes writes:—"Granite might become solid at a temperature that would keep felstone and trachyte still fluid, and these might solidify at temperatures which would keep molten all greenstones, basalts, and dolerites, so that from the very same stream of igneous matter proceeding from the interior to the surface of the earth the more readily fusible portions might be successively squeezed out, as it were, as the infusible ones solidified, and contracted in consequence of that solidification. This action might take place in spite of the greater specific gravity of the more fusible minerals, since the difference in the specific gravities would probably be small compared with the power of the eruptive force." And in a note he adds :—"The chemist is reminded of the fact, that if a mixture of metals, as, for instance, tin, bismuth, and lead, be melted, they will, as the mixture cools, have a tendency to solidify and crystallize out separately as the temperature of the mass reaches their respective melting points. This constitutes a great difficulty in large bronze castings." (Student's Manual of Geology, p. 92.)

I have now briefly traced the volcanic history of this remarkable mountain. The first igneous disturbances were apparently those connected with the formation of granite through metamorphism of the Lower Silurian sedimentary strata. This action was probably not unattended with some manifestations of a volcanic nature, all traces of which, however, were probably removed even before the period of the Upper Silurian formation; denudation, assisted by other physical agencies, having, as we have seen from the example in the West of Ireland, removed all the superincumbent strata and exposed the deep-seated metamorphic rocks. At a subsequent period, probably about the close of the Palæozoic epoch, volcanic disturbances recommenced, and the massive dolerites and granitoid rocks were protruded into, but not through, the granitic area. Simultaneously with this intrusion, or a little later, a lateral mass of molten rock was projected sufficiently near the surface to overcome the pressure of the overlying rocks, throughout a large area, but, partly on account of the distance from the volcanic focus, in conjunction with other causes, the eruption, though violent, was of a very temporary character, and the great volume of displaced materials falling back into the gulf still further checked its activity, so that the intumescent mass was never developed into lava or scoriæ.

Perhaps the most instructive feature in the physical history of this district is the evidence it affords of the intimate connexion between the granitic and the volcanic rocks. Prof. Jukes writes :—"If we could follow any actual lava-stream to its source in the bowels of the earth, we should, in all probability, be able to mark in its course every gradation from cinder or pumice to actual granite." (Student's Manual of Geology, p. 93.) Prof. Judd has recently demonstrated that in some of the western isles of Scotland this connexion can be traced in all its stages, and the ultimate development of the granitic rocks into contemporaneous lava flows, with their accompanying scoriæ, ash, and lapilli, is there fully exemplified. In the district described in this paper, the series, though not so complete, furnishes another remarkable illustration—showing the passage from granitoid rocks to others, which, though not actually volcanic, have, however, approached near enough to that character to give rise to aëriform explosions and the production of a rock analogous to volcanic agglomerate.

## V.—The Extent of Geological Time.[1]

By the Rev. Maxwell H. Close, M.A., F.G.S.;
President of the Royal Geological Society of Ireland.

THE question of the geological age of the earth has been of late very prominently before the minds both of geologists and physicists. There is no occasion to take up time by giving a sketch of the late history of the discussion. I beg leave simply to point out some considerations which seem to lessen considerably the weight of the physical objections to the great extent of geological time. Let us observe before proceeding further that we do not wish to avoid wholesome restriction of geological time. It seems to me that it adds greatly to the interest of geological investigation to know that we have not a wilderness of possibility before us as to the length of time and the consequent deliberateness of geological operations. If we feel inclined to complain that Sir William Thomson is rather severe upon us, let us reflect that in this matter he is generosity itself compared to a certain distinguished collaborateur of his, and moreover that if he lays a burden upon our shoulders, he supplies us with a good staff to help us in carrying it. He points out that while the earth was hotter than now, its energy was greater, and the rate of working of geological agents greater. This would lessen the need for greatly extended time. We should admit that there were, probably, two circumstances which would make that increased energy less readily available, and diminish the rate of its expenditure. Those are the cloud-covering that must have enveloped the earth to interfere with radiation, and the greater extent of sea and smaller extent of land, which is supposed to have existed in the earlier geological ages, which would lessen the amount of denudation by diminishing its area. The first physical objection that we shall now mention is that drawn from the supposed rate of cooling of our globe, and the time that would be necessary for it to reach its present thermal condition. Sir William contemplates granting the geologists 90,000,000 years, though he may have to allow them only 50,000,000. In making the calculation it is necessary to make two estimates and two assumptions, on which to found the calculation. The first estimated quantity is the increase of temperature per unit of depth in the crust of the earth, which he takes at 1° Fahr. for 54 feet. The second is the conductivity of the body of the earth, or at least of its less inward part. Mr. Mellard Reade has shown the great uncertainty there is as to both of these. The two *assumptions* are the approximately equable distribution of the temperature of the globe at its first solidification, and the constant difference of temperature between the surface and the interior, of more than 7,000° Fahr.

The next argument for the restriction of geological time which we shall consider is that the sun cannot be imagined capable of keeping by its radiation the earth's surface in a state fit for the support of

[1] Being a paper read before the British Association (Section C.), Dublin, August 21, 1878.

vegetable and animal life for a time as long as the geologist would require. If I might presume to express an opinion on the subject, it seems to me that this is the argument which is calculated to cause the greatest anxiety to geologists. The period of the sun's radiation depends upon two principal assumptions, not to mention some others of much less importance, and these are the amount of heat at the disposal of the sun, and his power of radiating it. As to the latter, his radiating power, the physicists have kindly come to our help and mitigated our difficulty considerably by showing us how to restrain his otherwise too lavish radiation when he was still young. We shall content ourselves with thanking them for their help, and pass to the other point. Now, then, as to the amount of potential heat that there was in the solar system nebula to be afterwards realized by the sun. This is calculated on two assumptions, both, it must be candidly confessed, very reasonable ones, yet both we must at the same time claim to be not proven. The first is, that the nebula whence the solar system was to be formed had no energy worth speaking of proportionately, but the potential energy of gravitation wherewith to start on its career of evolution; and the second is that the unit of gravitation, at least within the range of the original nebula, and of the resulting solar system, has always been constant. Dr. Croll's suggestion in answer to the first of these is well known —viz. that it may have been the very heat of the nebula which caused it to exist as such, and that its heat may have been produced by the collision of two cosmical masses. We shall not go into this now; we shall merely endeavour to remove the objection that has been made to it. It is admitted that such collisions occasionally take place, but it is objected that they are rare, and that the chance of any particular cosmical body colliding with another within a considerable number of millenniums is indefinitely small. Most true: but in the first place for how many cosmical æons were we waiting for our collision? On foot of this account the geologists have practically unlimited funds to their credit in the Bank of Time. But besides this there seems to be some misconception in this objection of the improbability of this collision. The very same accident or coincidence may be to one observer a matter of indifference, and perfectly credible on comparatively slender testimony, and it may be to another so remarkable and striking as to be not easily believed, or only to be explained as a direct interposition of Providence—according to the point of view of the observer, according as he happens to be concerned with the coincidence. It seems to me that the present objection has no weight; it has scarcely any meaning except from the anthropocentric point of view, and that cosmologists ought to consider cosmological questions from a higher standpoint. But, besides this, not only does Dr. Croll's suggestion afford relief to the geologists, but I respectfully submit that the physicists themselves might be glad to avail themselves of it.

We are told most truly that the falling together of the materials of a cold nebula is "a thoroughly intelligible source of heat." But what about the source of the cold nebula itself? Is that a thoroughly intelligible matter? I submit that if we try to trace the line of causation into a cold nebula, when we have got there we shall find ourselves in a *cul-de-sac*, and can go no further. Moreover, we are not entitled to take it as an ultimate fact without the strongest reasons. It is not the custom of the physicists to take refuge in Agnosticism as long as they can possibly avoid it. In other matters they will trace the steps of causation as far back as they possibly can. Let us then, instead of going back into a cold nebula which cannot be accounted for, take the other turn into a heated one, for which there is "a thoroughly intelligible source," in the relative motion of cosmical masses which we know to be an actual fact. We do not know that a cold nebula is a fact in this stage of the universe. All the nebulæ of which we know are apparently glowing with heat, and considering the apparent tenuity of them, and the enormous dimensions of some, it is highly probable that their heat is the result of the falling together of their parts. As to the gravitation attraction being the sole force that was to cause the molecular falling together of the materials of the nebula, we do not know that this was so. The shapes of some nebulæ and the behaviour of others by no means encourage the belief that the gravitation attraction is the sole connexion between their parts.

But as to the gravitative attraction itself, granting that it was the origin of the potential energy of the solar system nebula, do we know that the unit of gravitation is constant throughout the enormous interstellar space that has been traversed by our system since it first began to fall together? Recent physical speculations contemplate gravitation as being not an inherent essential property of matter itself. If it were so, we might well suppose it to be unchangeable, as inertia most probably is. But it is conceived of as depending upon the action of an external gravific medium, which might or might not be there. And there seems to be nothing to lead us to believe that the energy of that medium must be uniform throughout time and space. Some physicists conceive of that medium as being itself not amenable to the law of the conservation of energy; there is no inconsistency whatever in this. But it is rather a startling position to take up, and to avoid the necessity of doing so, Mr. Tolver Preston suggests that the gravific medium may be comparable in its structure to a gas with an exceedingly great yet limited mean excursion of its particles. This would limit the range of gravitation between two material particles, though we have now nothing to do with that. And he suggests that the light and heat which is supposed to be entirely dissipated and lost in space may not be really so—the luminiferous ether may be all the while paying back to the gravific medium, in some way unknown to us, the energy which it is expending in producing the heat of the countless suns. This would certainly be more in analogy with what we see around us of the transformation of energy. Now, let us join with this Poisson's idea that the so-called temperature of space—the whole radiation of the stars at any place—is not uniform, and it results from speculations made by physicists themselves, not in the interests of geology, that the unit of gravitation may not be constant throughout time, nor through the enormous length of interstellar space traversed by the solar system mass since it first began to fall together. We therefore cannot assert that we know what potential energy was possessed by that mass at that time, and what amount of heat for the sun to radiate at that time could be produced thereby. If there is too much boldness in these speculations, it is not the geologists who are accountable for that. Let us hope that the physicists may not withdraw them when they find that they may be turned to the advantage of geology.

We now come to the argument from the figure of the earth, taken in connexion with the circumstance that her rate of rotation must be diminishing—diminishing in consequence of the excess of the retardation caused by the tides over the acceleration caused by her contraction in cooling. The argument is this—when the earth consolidated she became as rigid as steel. Then, since the earth's figure is now so very nearly that due to her present rotation rate, she must have consolidated when her rotation was but little higher than now—that is to say, a comparatively short while ago. One reply which I have heard made by Professor Haughton is this—that when the earth had first solidified, her high temperature would cause rapid cooling; this would produce rapid contraction; this would cause acceleration of her rotation, which at first would overpower the tidal retardation, but after the lapse of a long time would sink to an equality therewith. Then the tidal retardation, even though remaining constant, would obtain the pre-eminence, and after the lapse of another long time bring down the rotation rate again to what it was at first solidification. So that, for all that appears to the contrary, the time that has elapsed since first solidification took place, consists of two long periods, and may be as great as geologists need wish for. This answer accepts, at least for the sake of argument, the steel rigidity of the globe, and is, I conceive, sufficient. But I would beg leave to point out another.

Sir William Thomson has himself very seriously shaken the foundation of the doctrine of the steel rigidity of our globe. This doctrine had formerly two grand supports, and, as far as I can find out, only two. Of these, Sir William has completely shattered one, that which rested on the amount of precession and nutation; and he has greatly discredited the other, for the present at least, that which rested on the magnitude of the ocean tides. He still considers that the evidence of the tides, as far as it goes, points to the high rigidity of the earth, but he shows that the semi-diurnal and diurnal tides are to be laid aside for one reason, and the semi-annual and annual for another. The only tides that he looks to for the determination of the amount of the earth's rigidity are the lunar fortnightly and monthly tides. But now observe, he says, that the Tide Committee of the Association "have not hitherto succeeded in obtaining any trustworthy indications of these tides," but the indications, such as they are, "seem to show possibly no sensible yielding, or, perhaps, more probably some degree of yielding of the earth's figure." "But though the testimony of these two tides is still so doubtful, let us accept it." The body of the earth yields very little to a fortnightly or a monthly change of straining force. But what about the 18·6 year variation of force connected with the revolution of the moon's nodes? Sir William Thomson says, "The absence from all the results of any indication of an 18·6 year tide is not easily explained without assuming or admitting a considerable degree of yielding." Observe how much clearer and stronger his language is now than before. There being no perceptible 18·6 year tide in the ocean, we conclude that the body of the earth must yield nearly as much as water to the variation of tidal force having that long period, though it will only yield a very little to a fortnightly or a monthly variation. The meaning of that is, that the rigidity of the earth, though so high as to amount, is as to quality a viscous rigidity. The peculiar character of a viscous solid is well known and illustrated by a stick of sealing wax. The earth, then, may yield as much as geologists need desire to the continued decrease of the centrifugal force of rotation. And therefore it may be hundreds of millions of years since she became solid, although her shape now so nearly corresponds to her present rate of rotation. There are quite independent considerations which make it most probable that the rigidity of substances at a much higher temperature than that of free fusion, but kept solid by pressure, is generally a viscous rigidity.

I would beg leave to suggest a method by which the yielding of the earth to the 18·6 year change of tidal force could in all probability be verified. If there be, as there certainly seems to be, "a considerable degree of yielding" to this in the body of the earth, it consists of an alternate rising and sinking of the whole equatorial belt of our globe together. This must alternately diminish and increase the rate of the earth's rotation—diminish it while the moon's ascending node is passing (retrogressively) for 8·55 years, from about 15 deg. W. of the winter to the same distance E. of the summer solstice, and for 10·05 years *v.v.* I believe that this change, though very small, is of an order of magnitude that could be detected by the astronomers if they would kindly undertake to look for it. They could not use the moon as their timepiece, her tables not being yet as correct as would be necessary in this case. But they have promised us revised tables of the Satellites of Jupiter, and when they shall have fulfilled their promise the innermost satellite would doubtless make a timepiece sufficiently accurate for the purpose.

Note.—The following coincidence seems worth mentioning, though doubtless only accidental. Professor Newcomb has thrown out the suggestion that certain unexplained irregularities in the moon's motion may be only apparent and caused by inequalities in the earth's rate of rotation. He has concluded that, if this be so, the earth was going slow in her rotation from 1850 to 1862, when she began to go fast. Now, from the above-mentioned cause the earth would go slow from November 26, 1852 (or very shortly after), to March 12, 1862 (or very shortly after), when she would begin to go fast again. The near coincidence is curious. But that is all; for while the 18·6 year tide in the body of the earth would keep the earth fast from 1862 only to June 30, 1871, Professor Newcomb's observations would show that the earth has been going fast, at least down to the latter part of last year—1877; and besides the changes caused by the 18·6 year tide could not, I believe, be as large as those deduced by Professor Newcomb from the apparent variations of the moon's motion.

## NOTICES OF MEMOIRS.

### I.—Geological History of the North American Lake Region.[1] By George Maw, F.L.S., F.G.S.

FROM Haysville I proceeded to Toronto, thence down Lake Ontario, with flat shelving shores here and there, with a low cliff of lake silt, in which, as far as I could observe from the steamer, glacial boulders were absent, though inland from the lake glacial drift was everywhere visible. The "Thousand Islands," at the eastern end of the lake, seemed to consist in part of glacial drift; some of the smaller islands of granite or a hard metamorphic rock, the whole densely covered with low deciduous woods and Hemlock Spruce. The low rocks were thoroughly rounded by ice action, possibly by post-glacial floating-ice passing over them, prodigious quantities of which are annually carried down the river during the spring thaw. The lake gradually narrows amidst an archipelago of little islands, and tapers imperceptibly into the great river. One of the most striking features throughout its length to Montreal is the absence of that sloping conformation of the land towards the river channel, the result of graduated subaërial drainage which is characteristic of most large river valleys, and the St. Lawrence seems placed inharmoniously in relation to the adjacent land contour. It has its channel between low banks, and that is all, and the observer fails to detect that graduated contour which the contributory ramifications of all ancient rivers have sculptured from their watersheds to their main channels of drainage; moreover, the St. Lawrence has an indecisive course, here splitting itself up against trifling obstacles into numerous channels, again uniting and spreading itself out into broad shallow lakes over the land, reminding one of the behaviour of a sudden rush of storm-water over a course unprepared for it. The St. Lawrence is obviously a new river and supplies a fresh line of drainage compared with the ages of many other rivers, and its history must be viewed in relation to the origin of the great chain of lakes of which it is the outlet.

The surface levels of the lakes step gradually upwards. Ontario is 235 feet above the sea; Erie, 564 feet; Huron, 595 feet; Superior, 627 feet above the sea. But their depths have no relation to the order in which they occur from the watershed to the sea, for the bottom of Ontario nearest the sea is 365 feet below the sea-level. The bottom of Erie is 462 feet above the sea-level of Huron, 145 feet above the sea; and of Superior, at the inland end of the chain

[1] Extracted from "American Notes," *Gardeners' Chronicle*, 1878, pp. 169, 170.

of lakes, 65 feet below the sea. Michigan is merely a great bay lying off from the main line of drainage. It is obvious that the present relative depths of the connected chain of lakes are inconsistent with their being merely the flooded sections of an old river valley, for the bottom of Ontario, the lake nearest the sea outflow, is 365 feet below the sea, and 600 feet below its own outflow into the St. Lawrence; the bottom of Superior, the lake furthest inland, is 65 feet below the sea, and 527 feet below the bottom of Erie, which intervenes, and no less than about 570 feet below the river-bed outlet of Erie.

A glance at the map will show how closely the watershed line environs the great lake district. The lakes receive no long rivers, and it is a mere narrow belt of land that drains into them, beyond which the drainage goes north towards Hudson's Bay, south towards the Mississippi, and east by the Ottawa. Several of the rivers running into the great lakes have on the map a curious aspect of continuity with the tributaries of the Mississippi system; this is especially noticeable in the case of the Wisconsin flowing into the Mississippi, and Fox River flowing north-east into Green Bay of Lake Michigan. The same relation is observable between the Wabash flowing into the Ohio, and the Maumee running into Lake Erie; and it is worthy of observation that the tributaries of the Maumee are bent back in a direction rather ranging with the direction of the confluents of the Wabash than with that of the Maumee, with which their main course forms an acute angle *against the stream.* If the lake area is a region of depression, it seems possible that the extremities of the confluents of the Mississippi may have been depressed towards the lakes, and the waterflow diverted northwards without the old valleys being obliterated.

We must set aside the view that the chain of large lakes is due to glacial excavation; for Ontario, the deepest of the lakes running east and west, is in lower latitude than Huron, the bottom of which is 510 feet above that of Ontario, and there is no high ground about Ontario from which ice could have originated as a preponderating mass, capable of excavating Ontario 600 feet deep; nor is there any such mass of *débris* anywhere to be seen about the lake as would represent such an excavation.

New York State, bordering on Ontario, abounds with small lakes, running north and south, between escars and drift ridges, evidently of glacial origin, and which have nothing in common with the direction or character of the larger lakes, which must be the result of the subsidence of the area, bounded by their environing watershed, resulting in a fresh basin of drainage towards the Atlantic, the former drainage of which was divided between the Mississippi basin, Hudson's Bay, and the Ottawa. The contour of the land surface north and south of the great lakes seems to indicate that the subsidence of the containing area was subsequent to the glacial excavation of the numerous small lakes running north and south, and it seems probable that the Niagara gorge, as well as the St. Lawrence, down to its junction with the Ottawa River, are of post-glacial origin.

II.—On the Geology of the Environs of Dublin.[1] By Prof. E. Hull, M.A., F.R.S.

The author remarked that the subject had been ably treated by the Rev. Maxwell Close, President of the Royal Geological Society of Ireland, in the hand-book issued by the Local Committee of the British Association. An excellent account of the same subject had been given by Mr. Baily, and also in the very interesting publication called "Science Gossip." It had been the habit to begin the meetings of the Section by giving a short description of the locality in which the Section met, and in conformity with that custom he would give a brief account of the geological structure of the environs of Dublin. Before doing so, he might refer to the physical features for the benefit of the strangers, who had honoured them with their presence. The first feature that strikes the stranger upon entering Dublin Bay is the beautiful range of hills, with their several sharp or prominent peaks, lying to the southward. These are the extremely northern points of the Dublin and Wicklow mountains, which might be called the south-eastern highlands of Ireland. They commence in the neighbourhood of Kingstown and Killiney, and extend in nearly a southerly direction to Waterford, a distance of about 40 miles, with an elevation at Lugnaquilla of 3039 feet. To the north and west of this range extends the great central plain of Ireland, which stretches from the shores of the Irish Sea, between Dublin and Dundalk, across the country towards Galway Bay. It is bounded on the south of this range of hills, which commences at the Devil's Bit, extending southwards towards the county Limerick, crossing the Shannon above Limerick, and going towards Clare and Galway; thus forming the outworks of the great south-western highlands, which includes the mountains of Kerry, Cork, and Waterford. To the north there is another range of hills of not so great an elevation, and then to the west are the western highlands of Galway, Mayo, and Sligo, including the beautifully picturesque tract of Connemara. All these hills are of older formations than the central plain. They rise from beneath that plain, throwing off the newer formations in every direction. It is a curious geological paradox that the oldest formations generally occupy the highest ground. As to the geological structure, it might be better to take the order of deposition or natural order of birth. The oldest formations in Ireland are represented in the neighbourhood of Dublin to the north and south of the bay. This formation is called the Cambrian, similar to the Lower Cambrian in North Wales. They consist of enormous thicknesses of reddish and green slates, grits, and quartzites traversed by great fissures. These beds are very well laid open along the railway cuttings at Bray Head, where some would have an opportunity of inspecting them on Saturday; also at the Hill of Howth, where the strata was of a precisely similar character. They were characterized by very simple forms of animal life—*Oldhamia* of two

[1] Read before the British Association for the Advancement of Science, Dublin, (Section C.), August 15, 1878.

species, and also by tracks and borings of marine worms. This formation was immediately succeeded by what was called the Lower Silurian, which formed the main tract of the country, ascending the mountains in some instances even to the summit of Lugnaquilla, the core of the range being granite. This granite had been intruded through the Silurian rocks, and, curiously enough, not through the Cambrian rocks, but had affected the Lower Silurian rocks to such a degree that, from being formed of fossiliferous slates and grits of a darkish grey and brown colour, they had been converted into what was called "metamorphic strata," accompanied by the development of certain minerals. Mica had been developed where these rocks came into close proximity with granite. Granite was, therefore, of a newer date than these Lower Silurian rocks, for otherwise the Lower Silurian would not have been metamorphosed by contact with the granite. The junction was very well seen in numerous places, especially at the foot of Killiney Hill, where the dykes of granite could be seen penetrating the slaty and micaceous schists, also at the remarkable gap, the Scalp, and on ascending Glendalough Valley. The chief limestones were to be found at the chair of Kildare, and on the east coast opposite Lambay Island. These were representatives undoubtedly of the Bala limestone of North Wales, and had yielded a magnificent series of fossils representing the Lower Silurian period. This brought them to the subject of the age of the Dublin and Wicklow mountains; when they were first elevated; when they first received their great foldings and contortions, and when the enormous mass of molten matter now constituting granite was first intruded amongst these bodies. To determine this question they had of course to refer to formations newer than the Lower Silurian. At the extremity of the Wicklow and Wexford range they found Old Red Sandstone resting discordantly on the upper edges of the Silurian rocks. Therefore, the Old Red Sandstone was newer than the period of metamorphosis, which was the period of the first birth of these mountains. Just as in Scotland, along the flanks of the Grampian Hills, they found the Old Red Sandstone resting upon the crystalline rocks, which were of the same age as those of the Dublin mountains. Thus they had in both countries similar phenomena. The Silurian rocks were upheaved and converted into land before the Old Red Sandstone period. He believed the age of the Dublin and Wicklow mountains might be placed at that interval of time which elapsed between the close of the Lower Silurian period and the commencement of the Upper Silurian period. The Old Red Sandstone was scarcely represented within the area described, except in the neighbourhood at Kiltorcan, on the borders of the counties Wicklow, Wexford, and Carlow. It had, however, yielded some magnificent ferns and other fossil plants which could be seen in the Museum of the College of Science. The next formation was the Carboniferous, which was, perhaps, the most important, extending over the plain north and south, and principally represented in the neighbourhood of Dublin. It consisted of three divisions—lower, middle, and upper. The middle was of an earthy character, darkened by carbonaceous material, probably that of marine algæ. The whole formation was undoubtedly a great marine or oceanic deposit. It was in the first place full of marine shells, the same as those existing in the sea at the present day. Taking a thin section of any specimen of Carboniferous Limestone, however dense and apparently unfossiliferous, let the slice be so thin as to be transparent under a microscope, and they would find it consisted of a mass of shells resembling those of the little animals of the simple forms of life which exist in such vast numbers over the floor of the ocean at the present day, namely, *Foraminifera.* The Carboniferous Limestone was in all about 3000 feet thick, so that the building up of the great organic formation over the floor of the ocean must have taken a period of indefinite duration. When they went to Kilkenny and Carlow, they found the representatives of the Middle and Upper Carboniferous series analogous to that of the British and Welsh Coal-fields. Professor Hull then proceeded to refer to glacial deposits. No one had contributed more to the elucidation of this subject than the Rev. Maxwell Close. He had shown that the whole of this part of Ireland was at one time covered by a thick sheet of ice, which has left its marks upon the solid rock wherever that rock has been sufficiently protected to prevent the marks being obliterated by time. Those who would be able to be present at the examination of Bray Head on Saturday would have an opportunity of seeing the glacial scorings and groovings upon the surface of the quartzite near Killiney Hill. Drift formations were well represented in the neighbourhood of Dublin. They consisted of three divisions. The oldest was Boulder-clay—a formation which disgusted and dismayed engineers and contractors, but had furnished a good deal of interesting speculation to geologists. It contained blocks of rock generally glaciated or worn by ice, grooved, and scored. Some of these glacial stones were to be found in the present excavations at Stephen's Green. The stones were not only grooved and scored, but had a polished surface, showing that they had been ground and rubbed over solid rock as the ice was moving along. Undoubtedly the Lower Boulder-clay was the result of the original ice-sheet which covered the whole country, moving in the neighbourhood of Dublin from the north-west towards the east and south-east, and, what was very remarkable, moving through the central plains over the hills which rise between it and the sea, by a force he was not going to speak further of. Let them just fancy that sheet of ice being obliged to pass from the lower ground over such hills as Killiney and Bray Head out towards the sea. The Lower Boulder-clay was succeeded by another series of drift strata, entirely different, consisting of stratified sands, gravels, and marine shells. A beautiful selection of these shells was open for examination at Howth, close to the telegraph-station at the beach, and in half an hour an excellent collection of glacial shells of the period might be obtained. These shelly gravels were, of course, deposited under totally different conditions from Boulder-clay, which underlay them, because they were evidently deposits which had been formed in the sea of the period.

These shelly gravels only covered portions of a lower tract of country in the neighbourhood of Dublin, and they ascend the flanks of mountains to the height of 1100 or 1200 feet above the sea, showing, he thought, that the land had subsided to that extent beneath the sea, so that only the mountains of higher elevations would rise above the level of the water and appear as islands. There was another very remarkable formation, that of the Upper Boulder-clay, which could be seen at Howth, and which succeeded that to which he had alluded. There was only one other formation to which he would refer, and that was the remarkable raised beach which extended along the eastern coast from Wicklow to the Giant's Causeway, round to Donegal. This raised beach was represented by a terrace of shelly gravel belonging to the neighbouring seas, and showed that the shore had been within a very recent period elevated from 3 to 4 or 10 feet in the neighbourhood of Dublin, and to a greater degree in the North. This beach was shown by the Esplanade at Bray, which was really an old sea-bottom raised five or ten feet above the original position. In the North of Ireland the shelly beach was found to contain some of those arrow-heads and flint instruments to which the President had alluded. They would see from what he had said that they had within a short compass a very considerable series of formations, and he hoped the sketch he had given would enable geologists, and those who took an interest in the subject, to better understand than they otherwise would some points of interest in the geological structure of the neighbourhood of Dublin.

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## III.—On some New Pre-Cambrian Areas in Wales.[1] By Henry Hicks, M.D., F.G.S.

During some recent researches in Wales the author has been able to add many new areas to the pre-Cambrian rocks already described. In these examinations he has been assisted at different times by Prof. Torrel, of Stockholm, Prof. McKenny Hughes, Mr. Tawney, F.G.S., and Dr. Sterry Hunt, of Montreal. The additional areas to be now added to those previously known are:—

1. Some cupriferous schists with their associated greenstone bands (the so-called intrusive greenstone of the Geological Survey) to the north of Dolgelly, and including a great portion of Robel Tawr.

2. Masses of granitoid rocks, porphyries, and greenstone breccias, in the neighbourhood of Pwllheli.

3. The porphyries and granitoid rocks forming Mynydd Mynytho, and extending in a northerly direction towards Nevin, including also Nevin mountain and the porphyries and greenstone breccias to the north-east of Boduan.

4. The Rhos Hirwain syenite and the so-called altered Cambrian beds to the west of that mass in Caernarvonshire, and also Bardsey Island.

[1] Abstract of paper read before the British Association for the Advancement of Science, Dublin (Section C.), August 19, 1878.

5. The granitoid rocks, felstones, and porphyries, forming the Rivals (yr Eifl) range of mountains.

6. The so-called altered Cambrian rocks to the west of the Penygroes porphyry.

7. The so-called intrusive granite in Anglesea, and the whole of the area marked as altered Cambrian in that island. In addition to these he has also extended some of the areas and defined more clearly the order of superposition of these rocks in Pembrokeshire. In North Wales, as in South Wales, he found that the pre-Cambrian rocks resolved themselves into three well-marked and very distinct types, and that these indicated separate formations, each of which, on careful examination, and when found in juxtaposition, proved to be unconformable to the other. At St. David's the granitoid rocks occur at the base, and, resting unconformably upon these, are found the quartz-felsites. These are again succeeded unconformably by the agglomerates, breccias, greenstone bands, and schists of the Pebidian group.

In North Wales this was also exactly the order in which the various rocks were found to succeed each other, but the middle or quartz-felsite group was found more largely developed in Caernarvonshire.

As this middle group had not previously been separated under a distinguishing name, the author now proposed to adopt for it the name *Arvonian,* from the Roman name *Arvonia,* and from which the present name of Caernarvon is derived. So many of the large ridges and lofty mountains of Caernarvonshire are composed of these felsitic rocks, that it appeared to the author and his friends that this name would be very appropriate for the formation. The distinguishing characters most marked in these three pre-Cambrian formations may be briefly summed up as follows:—

1. *Dimetian:* Granitoid gneiss and quartzose rocks.

2. *Arvonian:* Quartz, felsites, and porphyries (Helleflinta of Torrel; petro-silex rocks, Hunt).

3. *Pebidian:* Green and purple agglomerates and breccias, green chloritic schists, with massive greenstone bands, talcose schists, etc.

In these formations the bedding is usually easily recognized, but at present the actual stratigraphical thickness cannot be correctly estimated. It is perfectly clear, however, from the sections exposed, that each must have a vertical thickness of many thousand feet. That they have a very extended geological distribution over the British Islands is also daily becoming more and more evident.

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## IV.—On the Supposed Radiolarians and Diatomaceæ of the Coal-Measures.[1] By Professor W. C. Williamson, F.R.S.

THE author called attention to the *Traquariæ* of Mr. Carruthers, found in the Lower Coal-measures of Lancashire and Yorkshire, which small spherical objects that observer believed to be Radiolarians like those still living in existing seas. The author showed

[1] Read at a Meeting of the British Association, Dublin (before Section D, Biology), August 19, 1878.

that the radiating projections with which these spheres are surrounded were not siliceous spines like those of the Radiolariæ, but extensions of a continuous membrane which inclosed the entire organism, and which, therefore, could not have the spicular nature attributed to them. He then demonstrated that within this external membrane is a second inner one, which latter is fitted with numerous small vegetable cells like those shown to exist in the interior of fossil spores and reproductive cryptogamous capsules, found in the same beds as those which furnish the *Traquariæ*. These conditions are so different from those existing in any known recent species of Radiolarian as to lead Professor Williamson to reject the idea of their Radiolarian character. Their close organic resemblance to some obviously vegetable conceptacles found in the same Coal-measures suggest that the *Traquariæ* are also vegetable structures. The Mountain Limestone deposits of some British localities contain a vast multitude of minute calcareous organisms, which Mr. J. W. Sollas and other observers regarded as Radiolarians. These structures, however, seem to exhibit no satisfactory evidence of being so. In the first place, these organisms are calcareous instead of siliceous. It has been suggested that their siliceous elements were removed and replaced by carbonate of lime, but this appears to be most improbable. Professor Roscoe and Professor Schorlemmer agree in stating that they would require overwhelming evidence before they would be prepared to accept such an explanation of the present condition of these objects, or of the fact of the substitution of carbonate of lime for silica, which such an explanation renders necessary. Count Castracane has published[1] an account of a process by which he reduced numerous specimens of Coals to very minute quantities of Coal-ash, and has stated that he found in these ashes numerous marine and freshwater Diatomaceæ. Professor Roscoe kindly allowed one of his ablest assistants in his laboratory at Owens' College to prepare analyses of a number of Coals according to Count Castracane's method. The residual ashes of these preparations have been tested microscopically by Professor Williamson, and in no one of them can a trace of a Diatom be found. Beyond stating the fact, he is wholly unable to account for the discrepancy between his results and those of the Italian observer. So far as his present observations go, he finds himself compelled to conclude that we have no proof of the existence of Radiolarians or of Diatomaceæ in the British Carboniferous rocks.

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## V.—Underground Waters.[2] Fourth Report of the Committee on Underground Waters in those Districts in England where they are not at present used. By C. E. De Rance, F.G.S., Assoc. Inst. C.E.

The author referred to the great value of the maps of the Government Geological Survey as a basis for the investigation

[1] See Geol. Mag. 1875, Decade II. Vol. II. p. 414.

[2] Read before the British Association for the Advancement of Science, Dublin, 16th August, 1878 (Section C).

in question of the water supply. He stated that the area occupied by permeable formations capable of yielding water in wells sunk in suitable situations was no less than 26,687 square miles, which, receiving a rainfall averaging 30 inches a year, would yield up to wells not less than 6 to 15 inches, or a daily quantity of not less than 200,000 gallons for each square mile of surface, or a total quantity far in excess of that required by the population of England and Wales. The great value of these supplies for the towns and districts of the Midland districts was insisted on by reason of their purity, and from the absence of strong Parliamentary opposition, which is encountered in all large gravitation schemes, whether the water be proposed to be taken from natural lakes, as in the scheme for Manchester, or from artificial reservoirs, as in the proposal for Liverpool. The well-boring at Bootle, near Liverpool, completed for the Liverpool Corporation by Messrs. Mather and Platt, was described as of great interest, the boring having reached a depth of 1,000 feet without reaching the base of the New Red Sandstone. The Committee expressed a hope that this boring may be continued, as it will settle several questions, not merely of local interest, but of national importance.

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VI.—On the Rocks of Ulster as a Source of Water Supply.[1] By W. Traill, M.A.I., F.R.G.S.I., of the Geological Survey of Ireland.

THE author first contrasted the backward state of the study of hydro-geology in Ireland with its advanced progress in England. The necessity for better water supplies had been recognized by the larger towns, which had accordingly been supplied, but too many of those, with populations of 5,000 to 1,500 inhabitants, were still supplied only by shallow surface wells, a source universally condemned as scarcely possible to be free from sewerage pollution, the fruitful parent of disease. The two great systems of water supply were contrasted, that by catchment basins with large reservoirs, and that by deep wells or borings, the latter where practicable being undoubtedly considered the best. The rocks of Ulster were then reviewed with regard to their suitability as sources of water supply. The Lower Silurian rocks of Down, Louth, Armagh, and Monaghan did not possess the essential qualities necessary for success; neither did the granitic tracts of Mourne, Newry, or Rathfriland, nor the metamorphic rocks of Donegal and part of Londonderry, nor the districts of the Carboniferous Limestone. The New Red Sandstone formation, one of the great sources of water supply in England, was shown to occupy in Ulster a very limited surface area, in some districts yielding water by boring, and likely to prove productive in other places also, but requiring special selection of sites for operations. The Chalk and Hibernian Greensand formations were shown to be the great water-bearing rocks of Ulster, as evidenced by the large number of perennial springs along their outcrop. The geological basin of the Cainozoic in the counties of Antrim and

[1] Read before the British Association, Dublin, in Section C, August 19, 1878.

Londonderry was clearly demonstrative from the heights of the outcrop of the Chalk, up to elevations of a thousand feet; and its occurrence inside the basin, at Templepatrick and other places, was proof of its continuity below the basaltic plateau at a low level. The water, being held under hydrostatic pressure in the Cretaceous beds underlying impervious clays of the Lias or Keuper marls, required only to be tapped by boring through the overlying sheet of basalt to yield a practically inexhaustible supply of pure and wholesome water. The districts most favourably situated for thus yielding water supplies by boring were near Ballymena, Ballymoney, Coleraine, Antrim, etc. The author stated that for most localities the requisite depth to meet the Chalk could be readily calculated. He also enumerated the other water-bearing strata existing in the same sections, as at the lithomarge bed of the Iron-ore measures, and at the lower lithomarge bed, and also at the surface of the basalt if under a considerable head of drift. The author strongly advocated the adoption of boring for water supplies for certain districts in Ulster, as that system had been so advantageously adopted in England.

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VII.—The Progress of the Geological Survey of Ireland.[1] By Professor E. Hull, M.A., F.R.S., Director of the Geological Survey.

PROFESSOR HULL gave a short account of the progress of the Geological Survey of Ireland from its commencement in 1832, under the late General Portlock, R.E., down to the present day, stating that the whole country south of a line drawn roughly from Larne on the coast of Antrim to Sligo had been surveyed, while 160 Sheets of the Geological Map, on a scale of one inch to the statute mile, had been published. Along with these had also been issued 78 separate Explanatory Memoirs describing the structure and palæontology of 126 Sheets. It had been found necessary to revise the geology of the Leinster and Tipperary Coal-fields, the Carboniferous trap rock of the County Limerick, and the South-East portion of the country, including parts of Wicklow and Wexford. The Coal-fields of the North of Ireland had also been surveyed and published in maps both on the 6-inch and 1-inch scales; and it was also intended that the districts of the County Antrim containing pyrolitic iron-ores should be illustrated by maps on both scales. The district still remaining to be examined included the greater portions of Donegal, Tyrone, Fermanagh, Sligo, and Antrim. Professor Hull entered into a brief description of the geology of the various parts of Ireland.

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VIII.—On 'Hullite,' a hitherto undescribed Mineral.[1] By E. T. Hardman, F.C.S.

THE author stated that this mineral occurs in abundance at Carnmoney Hill, near Belfast, in the basalt forming the neck of a Miocene volcano. It has never been described before or analyzed,

[1] Read before Section C, Dublin, 20th August, 1878.

and has been referred to in the Survey maps and labelled in the Survey collections as obsidian, doubtless from its black colour and waxy lustre. In physical character it somewhat agrees with the Chlorophæite of Maculloch, but is entirely different in composition, which more resembles that of Delessite. From this, however, it differs essentially in colour, hardness, streak, and specific gravity, but it appears on the whole to belong to the ferruginous chlorite group. Physical characters—Colour, velvet black; hardness, 2; brittle; lustre, waxy to dull; very slightly affected by acids; occurs at Carnmoney and Shane's Castle, near Lough Neagh. The chemical composition of the mineral was given, and compared with those of Delessite and Chlorophæite. Its most remarkable characteristics are its low specific gravity and its resistance to the blow-pipe—both curious points, considering the large quantity of iron it contains. The author proposed to call the mineral Hullite, after Professor Hull, in commemoration of the valuable work he has done in elucidating the microscopic mineralogy of the basalts of Ireland. Professor Hull has examined the microscopic structure of the mineral, and of the rock in which it occurs, and has described the appearance presented by the mineral. Under the microscope it is of an amber brown colour, nearly opaque. It permeates the whole rock, filling the interstices, and inclosing the other minerals. It appears very much to assume the character of chlorite, and is undoubtedly a distinct mineral, and not a product of alteration.

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## IX.—On the Age of the Crystalline Rocks of Donegal.[1] By Professor W. King, D. Sc.

THE author said that the Crystalline Rocks of Donegal had been carefully studied, both in their petrological and geographical features, by Hampton, Scott, Harte, Griffith, Jukes, Blake, Harkness, and others; but among them some authors had succeeded in determining their geological age by means of fossils. It was true that the limestones in the Innis lower barony, in the northern part of the county, contained bodies which had been suspected to be the remains of corals, but it was to be regretted that none of these bodies, so far as is known, possessed sufficient evidence to enable palæontologists to offer a decided opinion as to their nature. Having been lately in Donegal, besides examining their mineral and structural character, he embraced the opportunity of endeavouring to find if any of the rocks occurring in this county, especially the Innis Lower Limestones, contained fossils. In the south coast division of Donegal, between Lough Foyle and Lough Swilly, where the least altered rocks prevailed, some of the limestones had apparently undergone so little alteration that it might be expected that they would retain the remains of any organisms originally inclosed in them. The bodies taken for fossils and corals consisted generally of white calcite, and they were occasionally found of a cylindrical shape, with what appeared to be internal radiating plates

[1] Read before Section C, Dublin, August 21, 1878.

Notwithstanding that the contrary had been expressed, he could not but strongly suspect that they were actually the remains of large corals. He had, however, succeeded in obtaining some true fossils from portions of the Innis Lower Limestone, that had scarcely undergone any change. He had not had time to examine them as closely as he would have wished, but they appeared to be Caradoc Bryozoa from the schists of Donegal. This was the first example, as far as he could ascertain, of an undoubted fossil having been detected in these limestones. The fact may be taken as evidence that these deposits and their argillaceous and siliceous masses are of Lower Silurian age, and it seems highly probable that the more intensely metamorphosed rocks in the north-west division of Donegal belong to the same geological period.

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## X.—The Origin and Succession of the Crystalline Rocks.[1] By Prof. T. Sterry Hunt, LL.D., F.R.S.

As a preliminary to a statement of the results of many years of study of the crystalline rocks in North America, the author proceeded to consider the question of their origin, which is still a subject of debate between Plutonists and Neptunists. The crystalline silicate rocks naturally divide themselves into three groups—namely, those indigenous stratified formations which have been called primitive, or primary; those masses to which, from their relations to contiguous rocks, geologists assign an exotic origin, and, in accordance with a generally accepted theory, have agreed to call igneous or plutonic; and a third and distinct group of rock-masses which, though like the last, clearly posterior to those encasing them, are now, by most geologists, admitted to be of aqueous origin. This third group includes metalliferous lodes, and various other crystalline veinstones, and is conveniently designated endogenous. It is not always easy to distinguish between the rocks of these three groups; there are not wanting those who have assigned an igneous origin to metalliferous lodes, and many still confound endogenous granitic veins with the mineralogically similar plutonic granites. In like manner, the distinction between the latter and the stratified granitoid gneisses is frequently not very apparent. That the movement of flow in extravasated plutonic rocks may give to the constituent minerals a stratiform arrangement, is a fact of which both exotic granites and doleritic dykes and masses afford illustrations. Moreover, the arrangement due to successive depositions upon the walls of a fissure may give to an endogenous mass a structure which simulates that of a sedimentary rock, and imparting to granitic veinstones a resemblance to gneiss; while a laminated structure sometimes results from the arrangement of the crystals developed in a cooling mass. Hence there are not wanting those who include under the head of plutonic rocks not only the clearly marked exotic granites, dolerites and diorites, but the granitoid gneisses, the massive bedded greenstones, and likewise the more schistose rocks with which these gneisses and greenstones are often so intimately associated that

[1] Read before the British Association, Section C, Dublin, August 19, 1878.

it is difficult to separate them. According to those who hold this plutonic view the crystalline rocks represent the igneous crust of the globe, and their frequent stratiform structure is due to agencies in great part anterior to the production of sedimentary rocks. In opposition to this view is that of the Neptunist, who, starting from the fact that the elements of an aqueous sediment may through the action of chemical and crystallogenic forces, pass into new combinations and acquire a new structure, argues not only that all indigenous crystalline rocks have had an aqueous origin, but that the exotic masses themselves represent the last stages in this process of alteration or metamorphosis of sedimentary beds.

Further inquiry into the chemical and lithological composition of the crystalline rocks, however, brings to light difficulties in the way of both of these hypotheses. To begin with the Plutonist view, volcanic rocks, both ancient and modern, are more or less nearly related in composition to the gneisses and the stratified greenstones, but we seek in vain among undoubted volcanic or igneous rocks for the chemical representatives of the masses of serpentine, olivine, steatite, chlorite, quartzite, magnetite, oligist, and limestone, which appear in the primary formations, and have, all of them, by geologists of the school in question, been regarded as of igneous or plutonic origin. To account for the presence of such rocks among the more or less felspathic aggregates—chiefly gneisses and greenstones, which make up the greater portion of the crystalline formations—three hypotheses have been imagined by Plutonists. According to the first of these, the earth's interior is a reservoir, from which at times have been ejected not only basic and acidic felspathic rocks, but molten masses of olivine, iron-oxide, quartz, and limestone. Other geologists of this school have sought to account for the presence of some of these exceptional rocks by a process of so-called segregation, which would assimilate them to endogenous masses. The chemical and geognostical difficulties in the way of both of these hypotheses have, however, led to their general rejection for the third, which supposes these rocks to have been formed by a subsequent local alteration of portions of the ordinary plutonic rocks. From acknowledged cases of alteration or replacement in mineral species, which result in pseudomorphs, and from the more frequent cases of envelopment and isomorphism which have been taken for examples of pseudomorphism, it was argued that many species are capable of being changed into others by the loss or addition of certain elements, so that the resulting body often contains no portion of its original constituents. Extending this view from single crystals to rock masses, it was maintained that different portions of an igneous or plutonic formation, whether basic or acidic, might be transformed into serpentine, chlorite, or limestone. Those changes were supposed to depend on the action of water, which, aided by heat, was regarded as the efficient agent in the local alterations of plutonic rocks. At the same time, the adjacent sedimentary strata were supposed to share in these changes, thus giving rise to what have been called contact formations. In their latest form these doctrines have been well set forth by Von Lasaulx and by Knop. This third hypothesis then proposes to account for the presence of various exceptional varieties of rock among ordinary plutonic formations, by supposing that limited portions of these have at different times been the subject of very unlike chemical processes, resulting in their complete change into new forms of rock by what has been called pseudomorphic alteration, or metamorphosis. As, however, such a conversion involves a change not only of form, but of substance, it has been more properly designated a metasomatosis.

We have next to consider the Neptunean views as ordinarily expounded. This, while it accounts by sedimentation for the stratiform arrangement of the crystalline rocks, and explains the existence therein of beds of iron ores and limestones, still presents many of the difficulties which are encountered in the Plutonist view. If, as most Neptunists maintain, the great crystalline series have been derived from the alteration of uncrystalline ones, which were not only similar to those of Palæozoic and more recent times, but are, in fact, portions of those which in adjacent regions are still known to us in their original unchanged condition, how are we to explain the genesis of the felspathic and hornblendic rocks which predominate in these crystalline formations? The sandstones and shales from which in this view they are supposed to be formed could never by themselves give rise to the rocks in question, since they are deficient in the alkalies, and to a greater or less extent in the other bases required for the production of the constituent silicates. To explain their origin, therefore, it becomes necessary to admit the introduction of these various bases from without, and to suppose a series of metasomatic processes more wonderful than those imagined by the Plutonist. The latter, by his hypothesis, has already at hand felspathic and hornblendic rocks, which are to be the subject of metasomatosis, while the Neptunist has only the products of their decay. In either hypothesis, we have to account for the presence in the primary formations of beds and interstratified masses of a great number of exceptional silicated rocks, very distinct in composition from any mechanically-formed sediments, including not only silicates like serpentine, olivine, steatite, chlorite, pinite, garnet, epidote, and hornblende, but of pure orthoclase, as well as of triclinic felspar. Each of these species would require for its production from any ordinary igneous or aqueous rock a separate and independent metasomatic process, involving the addition of certain elements, and the abstraction of others, until the whole heterogeneous crystalline series was complete. The author illustrated these views by examples from recent writers, and concluded that the hypothesis of metasomatosis, as maintained both by Plutonists and Neptunists, supposes the operation in solid rocks of processes of circulation, absorption, elimination, selection, and aggregation scarcely to be equalled in the economy of highly-organized beings, and not easily imagined in the masses of the mineral kingdom. Certain geologists suppose the existence of two classes of crystalline stratified rocks, the one Neptunean, and consisting of altered portions of Palæozoic or more recent sediments; and the other—more ancient—which may be either Neptunean or Plutonic in origin. The history of geology gives many examples of crystalline formations which have been in turn assigned to various geological horizons, from the Cainozoic to the base of the Palæozoic, but have since been found to belong to a pre-Palæozoic period. In the opinion of the author, we have no good and sufficient reason for believing in the present existence of any uncrystalline representative of these crystalline formations, or of any such formation which is not pre-Silurian, if not pre-Cambrian, in age. There are, however, many examples of local alterations of later sediments by hydro-thermal action, which has developed in these many crystalline minerals identical with those found in the more ancient rocks.

The advocates of the Neptunean hypothesis have, for the most part, sought for the origin of the crystalline rocks in sediments of a later date, of which the uncrystalline representatives are still to be found. There are, however, reasons for believing that in Eozoic, or pre-Cambrian times, there prevailed chemical activities dependent upon greater subterranean temperature, different atmospheric conditions, and abundance of thermal waters, and that under these circumstances were deposited the materials for the crystalline rocks. There have not been wanting those who have sought in similar hypothetical conditions for the origin of these rocks. De la Beche, in 1834, imagined them to be chemical deposits due to the action of the heated ocean upon the earth's primeval crust before the dawn of life. The author's researches into the composition and structure of the crystalline rocks, conjoined with his studies of the chemistry of natural waters, led him, in 1860, to reject the hitherto received view of the epigenic or metasomatic origin of serpentine, steatite, chlorite, and similar rocks, and to maintain their derivation from silicates formed by chemical processes and deposited in the water of lakes or seas. This view he soon after extended to the various other exceptional rocks found in crystalline formations which it was, in 1864, asserted had been "formed by a crystalline molecular re-arrangement of silicates generated by chemical process in waters at the earth's surface." In elucidation of this view the author referred to the insoluble silicates now separated in the evaporation of many natural waters, to the formation from the earliest times to the present of deposits of serpentine, sepiolite, glauconite, and of aluminous silicates allied to chlorite, which are found either forming beds or filling the cavities of various marine organic forms, from the foraminifers of to-day to the crinoids of Palæozoic time, and the *Eozoon* of the Laurentian. The formation in modern times of crystalline zeolites and quartz in thermal waters was also cited in illustration of this view of the generation of various mineral silicates by causes now in operation which, it is believed, were far more active in Eozoic times. This was not, as had been already suggested by others, a process confined to a seething primeval ocean before the advent of life, but was continued through long ages under varying chemical conditions, and was contemporaneous with the deposition of successive strata of limestone and detrital matters. The argillaceous portions of these, it is conceived, may have taken part in the reactions with thermal waters. We have thus, in the opinion of the author, a reasonable mode of accounting for the origin of the various rocks of the crystalline formations, and a consistent and complete Neptunean theory which does not involve the aid of metasomatosis. It has, since it was proposed eighteen years ago, met with the approval of many whose studies have made them the fittest judges of its reasonableness. Among those who have either formally given their adhesion to it, or have enunciated similar views, may be mentioned the names of Delesse, Renard, Gümbel, Credner, Alphonse, Favre, and Gastaldi.

The chemical activities concerned in the production of the various silicates have doubtless suffered gradual change and diminution through the successive ages of Eozoic time, from which have resulted mineralogical and lithological differences in the crystalline terranes. Each of these includes quartzites and limestones, in which latter certain silicates, such as serpentine, hornblende, and micas, are occasionally found. It is in those aluminiferous rocks, which are without lime or magnesia, that are seen the essential and characteristic differences dependent, as long ago pointed out by the author, upon a decrease in the proportion of alkalies. As we pass from the older to the younger of the Eozoic terranes, the felspar, orthoclase, and albite become partially or wholly replaced by silicates like muscovite, damourite and paragonite, and finally by andalusite, fibrolite, cyanite, and pyrophyllite. The author alluded briefly to the changes by which the ancient aqueous deposits were transferred into crystalline stratified rocks by what Gümbel has designated as diagenesis, as distinguished from their supposed origin by epigenesis or metasomatic change. The question of the relation of the indigenous rocks to the endogenous and exotic masses included in them was noticed, the author alluding to the hypothesis which he has elsewhere maintained that the source of all exotic or eruptive rocks is to be found in the displacement or extravasation of ancient deposits of Neptunean origin.

Coming to the second division of his subject, the author asserted that the study of the crystalline rocks of North America shows the existence of several distinct groups or terranes. The Laurentian, which is the most ancient, includes in its lower part a mass of unknown thickness of granitoid gneiss, often hornblendic (Ottowa gneiss), succeeded, perhaps unconformably, by what has been called the Grenville series, consisting of similar gneisses and hornblendic rocks, with intercalated quartzites and iron ores. These two divisions make up together the Lower Laurentian of Logan, of which the thickness in Canada may greatly exceed 20,000 feet. The Norian, which is the Upper Laurentian, or Labradorian of Logan, rests unconformably upon the Laurentian, and is remarkable for a great development of rocks composed chiefly of Labradorite, or related plagioclase felspars, which have been called Labradorite-rock, or Norite. The interstratified gneisses, quartzites, and limestones of the Norian are not unlike those of the Laurentian. This series, which abounds in great beds of titanic iron-ore, has a volume which may exceed the thickness of 10,000 feet assigned to it by Logan. The Laurentian is in many parts overlaid by the Huronian series, which is characterized by a great development of greenstones, generally hornblendic, with epidote, chlorite, steatite, serpentine, and soft hydrous mica-schists, often called talcose, besides argillites, quartzites, and limestones, generally magnesian. It abounds in metalliferous deposits, including magnetic and specular iron-ores, chrome, and sulphurets of copper, iron and nickel, and has assigned to it in different regions a thickness of from ten to twenty thousand feet.

In many parts of North America there exists a great development of rocks characterized by the predominance of orthofelsite, or petrosilex, often becoming a quartziferous porphyry. This, which is apparently the helleflinta of Sweden, was regarded as eruptive until in 1869 the author showed it to be a stratified series with some associated quartzites and schists, and then included in the lower part of the Huronian. Hitchcock, who has since studied these rocks in New Hampshire, has called them Lower Huronian. From their absence in many localities at the base of the typical Huronian, it is conjectured that they may belong to a more ancient and distinct series. The Montalban, or White Mountain series, is characterized by micaceous gneisses, generally called granites, which pass into quartzose and felspathic mica-schists, often abounding in garnets, staurolite, fibrolite and cyanite. Great masses of dark green gneissoid hornblendic rock, very distinct from the Huronian greenstones, abound in the Montalban, which also includes beds of a very peculiar olivine-rock, beside quartzites and crystalline limestones. This series abounds in endogenous granitic veins, containing muscovite, beryl, tourmaline, apatite, and oxide of tin. It probably equals the Huronian in thickness, and is supposed to overlie it. The Taconian series includes a great volume of characteristic mica-schists, often quartzose, but seldom distinctly felspathic, and frequently consisting in large part of damonite, or of pyrophyllite. Some of these, like the schists of the Montalban, include garnet and chiastolite. They are associated with quartzites, and with dolomites and limestones, all of which are also frequently micaceous. Associated with these are found serpentines and granular hornblendic rocks of a peculiar type, very unlike those of the preceding groups and much less crystalline. The quartzites are in large part detrital rocks. This series, which yields the statuary marbles of North America, has a thickness of about 5,000 feet, and is the Lower Taconic of Emmons. It is found reposing alike on the Laurentian, Huronian, and Montalban, and is overlaid, in apparent unconformity, by the Upper Taconic, which is identical with the Quebec group of Logan. This, which consists of many thousand feet of sandstones and argillites, with some limestones, includes among its strata organic forms belonging to various divisions of the Cambrian up to the Arenig. The Taconian, although containing an undescribed unguloid shell, and a so-called *Scolithus*, is, by the author, considered provisionally as distinct from the Cambrian. It has yielded in Ontario, besides *Scolithus*, the *Eozoon Canadense*, and may, perhaps, be regarded as the connecting link between the Eozoic and Palæozoic ages.

The Upper Taconic, or so-called Quebec group, in Eastern North America, is separated by a stratigraphical break from the succeeding portion of the Cambrian, the Bala group (Trenton, Utica, and Lorraine); while, on the contrary, the supposed discordance in the regions just mentioned at the summit of the latter, corresponding to the division between Cambrian and Silurian in Wales, appears to have been based on a misconception. There is, however, an important palæontological break at this horizon connected with a great deposit of barren detrital rocks, which marked the close of the Cambrian period, and the author records his opinion that the name of Lower Silurian, as well as that of Siluro-Cambrian, which he, with others, has applied to the Bala or upper division of the Cambrian, is to be rejected as being historically incorrect, and as tending to perpetuate false views of the palæontological relations between these and the succeeding rocks. The early advocates in North America of the notion of the metamorphism of Palæozoic rocks taught, in the first place, the stratigraphical equivalence of the Taconic, or L. and M. Cambrian, with the U. Cambrian, and further maintained that these rocks had suffered various degrees and kinds of metamorphism, as the result of which they had assumed, in different areas, the characters of the Taconian, Montalban, Huronian, and Laurentian; the lithological differences between these several series being regarded as marks of the greater or less alteration which it was supposed these uncrystalline Cambrian sediments had undergone. Other geologists have imagined portions of these same crystalline formations in North America to be altered strata of Silurian, Devonian, and even of Triassic age. The great groups of Eozoic rocks already described constitute, however, in the author's opinion, as many great stratified series, which, before the Cambrian time, existed in their present crystalline condition, and had been successively subjected to the accidents of uplift, contortion, and denudation, so that the newer Eozoic groups were, at the beginning of the Palæozoic period, distributed irregularly over the floor of fundamental Laurentian gneiss. These various crystalline groups are found, with a singular persistence and uniformity of ethnological character, from Alabama to Newfoundland, along the Atlantic belt, and thence westward through Canada, to the great lakes, and beyond, in the vast region of the Cordilleras to the Pacific slope. The author had some years since pointed out the remarkable similarity between the various crystalline groups of North America and the crystalline rocks of the British Islands, and had lately been able, by new observations, to confirm his conclusions. Among the crystalline formations of Donegal he had indicated representatives of Laurentian, Montalban, and Huronian, and the latter he had recently observed largely developed in Argyleshire and Perthshire. To the Huronian, also, he refers the green schists of Anglesea and Carnarvonshire, in both of which regions the orthofelsite, or helleflinta series at the base of the Huronian (the so-called porphyries), and likewise the more ancient gneisses, are well represented. He would, however, leave this subject to his friend, Dr. Henry Hicks, who has so happily mastered the obscure problems of the pre-Cambrian geology of Wales. The studies of Gastaldi and others enable us to assert that similar series of ancient rocks occur in the same order in the Alps; and we infer that the chemical and physical conditions which presided over the production of the crystalline stratified rocks were world-wide.

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## XI.—British Association for the Advancement of Science, Forty-eighth Meeting, Dublin, August 14th, 1878.

### A.—Titles of Papers Read in Section C. (Geology).

*President.*—John Evans, D.C.L., F.R.S.

The President's Address. (See p. 411.)

*Prof. E. Hull, F.R.S.*—Sketch of the Geology of the Environs of Dublin. (See p. 457.)

*J. Nolan, M.R.I.A.*—On the Ancient Volcanic Districts of Slieve Gullion. (See p. 445)

*W. Mattieu Williams, F.R.A.S., F.C.S.*—Notes on the Glaciation of Ireland and the Tradition of Lough Lurgan.

*W. H. Baily, M.R.I.A., F.G.S.*—Notice of some additional Labyrinthodont Amphibia and Fish from the Coals of Jarrow Colliery, near Castlecomer, Co. Kilkenny.

*W. Pengelly, F.R.S.*—On the Exploration of Kent's Cave. Fourteenth Report.

*R. H. Tiddeman, M.A., F.G.S.*—Sixth Report on the Victoria Cave, Settle.

*Prof. Alexander Macalister, M.D.*—Report on Fermanagh Caves.

*C. E. De Rance, F.G.S.*—Fourth Report of Committee on Underground Waters. (See p. 462.)

*W. Pengelly, F.R.S.*—On the relative Ages of the Raised Beaches and Submerged Forests of Torbay.

*Isaac Roberts, F.G.S.*—Experiments on Filtration of Sea Water through Triassic Sandstone.

*V. Ball, M.A.*—On a new Geological Map of India.

*Prof. W. C. Williamson, F.R.S.*—On the Supposed Radiolarians of the Coal-measures. (See p. 461.)

*The President.*—On some Fossils from the Northampton Sands.

*W. H. Baily, F.G.S.*—On some Irish Fossils.

*J. Nolan, M.R.I.A.*—On the Metamorphic and Intrusive Rocks of Tyrone.

*T. Sterry Hunt, F.R.S.*—On the Origin and Succession of the Crystalline Rocks. (See p. 466.)

*H. Hicks, M.D.*—On some new pre-Cambrian Areas in Wales. (See p. 460.)

*W. Williams.*—On the *Cervus megaceros.*

*W. A. Traill.*—The Rocks of Ulster as a source of Water Supply. (See p. 463.)

*J. W. Davis.*—On the Occurrence of certain Fish Remains in the Coal-measures, and the evidence they afford of the freshwater origin of the Coal-measures.

*G. A. Lebour.*—On the Discovery of Marine Shells in the Gannister Beds of Northumberland.

*R. A. C. Godwin-Austen.*—Report on proposed Kentish Explorations.

*W. Jolly, H.M.I.S.*—Report on Fossils of the N. W. Highlands of Scotland.

*E. T. Hardman, F.C.S.*—On the Influence of Strike on the Physical Features of Ireland.

*E. T. Hardman, F.C.S.*—On *Hullite*; a hitherto undescribed Mineral, with Notes on the Microscopic Appearances, by *Prof. Hull, F.R.S.* (See p. 464.)

*Prof. Hull, F.R.S.*—On the Progress of the Geological Survey of Ireland. (See p. 464.)

*Rev. H. W. Crosskey.*—Report of the Committee on Erratic Blocks.

*Dr. T. Sterry Hunt, F.R.S.*—On the Geological Relations of the Atmosphere.

*Prof. Herschel.*—Report of Committee on the Conductivity of Rocks.

*Prof. W. King, D.Sc.*—On the Age of the Crystalline Rocks of Donegal. (See p. 465.)

*Prof. E. D. Cope.*—On the Saurians of the Dakota Cretaceous Rocks of Colorado.

*Prof. James Nicol, F.R.S.E.* — On some New Fossils, *Eribollia Mackayi*, from the Quartzites of Loch Eriboll and other parts of the Western Highlands of Scotland.

*Alphonse Gages, M.R.I.A.*—On the Influence that Microscopic Vegetable Organisms have on the Production of Hydrated Iron Ores.

*Prof. O'Reilly, M.R.I.A.*—On the Correlation of Lines of Direction on the Globe, and particularly on Coast Lines.

*Rev. Prof. Haughton, M.D., F.R.S.*—On the Earth's Axis.

*Rev. Maxwell H. Close, F.G.S.*—Concerning the Extent of Geological Time. (See p. 450.)

*C. E. De Rance, F.G.S.*, and *Captain R. A. Feilden, R.A.*—Geological Results of the late British Arctic Expedition.

B.—Titles of Papers, Bearing upon Geology, Read in other Sections.

*Joseph Lucas.*—On the Hydrogeological Survey of England. (*Section G.*)

*Sir Victor Brooke, Bart.*—On certain Osteological Characters in the *Cervidæ* and their probable bearings on the past History of the Group. (*Section D.*)

*W. Morris.*—On the Temperature of the Earth within. (*Section A.*)

*Prof. Henry Hennessy.*—On the Limits of Hypotheses regarding the Physical Properties of the Matter of the Interior of the Earth. (*Section A.*)

*I. Roberts.*—The Filtration of Salt from Sea Water into Wells in the Trias Sandstone. (*Section G.*)

## REVIEWS.

I.—West Yorkshire. An Account of its Geology, Physical Geography, Climatology, and Botany. Part I. Geology. By J. W. Davis, F.G.S. Part II.—Physical Geography and Botanical Topography. By J. W. Davis and F. A. Lees. 8vo., pp. 414, with two maps and twenty-one plates. (London, L. Reeve & Co., 1878.)

THE importance of the county of Yorkshire, the large area it includes, and the number of formations therein represented, have always rendered it an attractive field to the geologist. The very mention of Yorkshire calls to mind the names of William Smith, John Phillips, Buckland, Young, and Bird, and a host of others, to say nothing of the valuable publications of the Government Geological Survey.

The first Survey Memoir having any reference whatever to this county was published in 1861, and has been followed by a few others, mostly, however, treating of some limited area, such as a coal-field, and not covering any large extent of country. The process of mapping has nevertheless been slowly going on, and we may hope to be favoured some day with the Survey's opinions on the Ridings; or, Yorkshire as a whole.

A door has thus been left open in the mean time for others to supply the growing want felt here, as elsewhere, of a more generalized treatise than is afforded by these detached memoirs. Accordingly, in 1863, Mr. J. G. Baker published a work on North Yorkshire, and so set an example and furnished a model whereon to found the work, of which the first volume lies before us.

The portion devoted to geology extends over the first 228 pages, and appropriates to itself all the plates, and one of the maps for its illustration.

The first thing one notices on opening the book is an excellent and extremely interesting "Bibliography," chronologically arranged, commencing with a paper published by Lister in 1674, and carried down to the end of the year 1876. The introductory chapter, which follows next, is devoted to a sketch of the physical and geological features of the district. To this succeeds a series of chapters on the different geological periods to which the various rocks found in it belong, namely,—Post-Tertiary, Triassic, Permian, Carboniferous, Devonian (?), and Silurian. They are taken in ascending order, the Carboniferous, owing to its economic importance, coming in, of course, for the "lion's share" of attention. In each case the author briefly describes the nature and characteristics of the component beds, giving, when occasion warrants it, details of the more important sections. With each series of beds we find a list of its fossil contents, and occasionally a few words as to the probable conditions under which it was deposited.

The oldest rocks of this area are the Green Slates and Porphyries of Sedgwick, here classed as Lower Silurian, from which it will be seen that the author follows Murchison's classification. We are left to infer that the beds doubtfully classed as Devonian are certain "red conglomerates" at the base of the Mountain Limestone, and resting in hollows in the Silurian slates below; at all events they have a chapter to themselves. No fossils have been found in these conglomerates "except such as are inclosed in the Silurian stones it contains."

The Permians are treated of separately, and the existence of a considerable break at this locality between them and the Coal-measures insisted on, though their relation to the overlying Trias is not mentioned. The red and purplish-red Plumpton Grits, hitherto classed as Permian, are now, on the authority of the Geological Surveyors, relegated to the Millstone Grit series, which is here immediately overlain by the Permian beds.

Arrived at the Trias, we become aware of a slight change in the method of treating the component beds, for both the list and description are in descending order. In the preceding formation the list was in descending order, the description in ascending; whilst in the Silurian and Carboniferous both lists and descriptions are in ascending order. Variety, though charming, may prove sometimes, as in the present instance, rather confusing.

The fashionable "Glacial Period," which follows on the Trias, is fully dealt with, and we read of a "great glacier" 1500 to 2000 feet thick, and of another "eight miles broad and at least 700 or 800 feet deep." These ice-giants do not appear to have troubled themselves about excavating lake-basins; but merely to have passed their time in scratching the rocks over which they passed, and in transporting huge rock fragments from place to place. Some remarkable examples of erratic blocks of Silurian age that have been stranded on the Mountain Limestone of Norbar, near Clapham, are figured on plates xiv. and xv. The Drift deposits are very irregular in their mode of occurrence; thus, "on the synclinal south-west of Carlton, drift is exposed at Park Head Quarry at a height of 1050 feet; other parts of the same synclinal at a height of not more than 600 feet are devoid of drift. As a rule the thickest deposits are in the valleys and on low grounds; they are thinner on the hill-sides, and either very thin or absent on the grit and limestone ridges which usually form the summits of the highest hills."

With the succeeding Post-Glacial beds the first part closes, and we start over the ground afresh with an eye to its physical geography and topographical botany, especially the latter. Omitting the long list of botanical names, it is, from its very nature, far more "readable" than the foregoing.

The plates, which bring up the rear, are diagrammatic rather than elaborate, and are well suited to the purposes for which they are intended. One can only wish that a few more had been added giving views illustrative of the different landscape effects produced by the several formations, as in the Survey publications. The maps, stowed away in pockets in either cover, are on a scale of 4in. to the mile, and carefully finished. The geological one will certainly, as Mr. Davis hopes, "be of service to practical geologists, the more so that it embraces districts for which the Survey Maps are not yet published"; whilst the work itself will be heartily welcomed by all, the completion of the second volume looked forward to, and doubtless not a few will wish that yet a third may be added that shall comprise the Zoology of this interesting district. B. B. W.

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II.—The Geology of the Emperor Francis-Joseph's Aqueduct at Vienna. A Study of the Tertiary Formations on the West Flank of the Alpine Portion of the Neighbourhood of Vienna. (Geologie der Kaiser Franz Josefs Hoch-quellen-Wasserleitung. Eine Studie, etc.) By Felix Karrer. With Twenty Plates, and numerous Illustrations in the Text. Published for the Imperial Royal Geological Institute. 4to. 420 pages. (A. Hölder, Vienna, 1877.)

THIS is a very fine large volume, brought out by the Austrian Geological Survey, at the expense of the State, and elaborated by the care of that excellent geologist and palæontologist Felix Karrer, with the co-operation of Suess, Fuchs, Jellinek, von Sacken, Teller, and many other friends, whose aid he acknowledges in the preface.

The great Aqueduct lately constructed to supply Vienna with water from the Kaiserbrunnen, distant $11\frac{3}{4}$ Austrian miles, and the Stixenstein Springs, about $9\frac{1}{2}$ Austrian miles from the main reservoir at the Rosenhügel, and thence by pipes into the city, is the subject of this noble work. The nature and localities of the sources, and the topographical features and geological structure of the ground, are the main objects in view, besides the gradients and the engineering and architectural characters of the actual works, as conduits and chambers at the springs, open channels, tunnels, bridges, and reservoirs.

The geology of the Vienna Basin is treated of in a general way in the Introduction; and a valuable list of books and memoirs bearing on the subject, from 1500 to 1875, is appended. Additions to this, down to 1876, are given in the Appendix, at p. 403. The twelve large plates of well-drawn sections, illustrating the line of the Aqueduct, with their associated plans and sketches of the country, elucidate the physical geography very clearly; and the fine geological map, by Th. Fuchs, of the neighbourhood of Vienna, including the Rosenhügel, and forming pl. 19 (published also in vol. ix. of the Transactions of the Geological Institute of Vienna), adds greatly to the value of the work.

The formations traversed by the Aqueduct from the Kaiserbrunnen on the S.W. (191·30 Vienna fathoms above the Danube water-mark at Vienna) to the Rosenhügel on the N.E. (46·28), on which the main reservoir is situated, comprise *Post-Tertiary*—Alluvium and Diluvium; *Tertiary*—the Congeria-beds, the Sarmatian beds, the Mediterranean beds; *Triassic*—the Upper Trias or Wetterstein-limestone, the Guttenstein-limestone, the Werfen-schists; *Older Rocks*—Grauwacke-schists.

The Triassic rocks come to-day at the Kaiserbrunnen, resting on old schists, in which the valley of the Schwarza is here cut for some distance. Congeria-beds succeed as far as Ternitz, where the broader valley is mostly coated with alluvium. Tertiary deposits are again met with when the Aqueduct takes the hill-sides towards Baden, where there is an exposure of the Triassic limestone, surrounded with the Mediterranean Tertiaries. At Mödling the Trias is seen, with gypsum; and the Sarmatian Tertiaries form most of the ground to the Rosenhügel, beyond which the ground falls, for about half an Austrian mile, to the valley-deposits of the present river.

The branch Aqueduct from Stixenstein (160·77 Viennese fathoms above the Danube, and 9½ Austrian miles from Vienna) begins on Triassic limestones and schists, and follows the valley-deposits of the local stream, to join the main line at Ternitz.

Besides containing many maps, plans, and diagrams, the text is enriched with nearly a hundred numbered vignette sketches, mostly geological, giving the local details of numerous well-executed sections, supplemental to the longer sections on the plates.

The description of the Aqueduct and the ground traversed by it is given in chapters according to the successive segments. The geology, including the palæontology, is fully given, together with references to all the authors and workers who have originated or added to what is known of each locality.

The quantity, temperature, and constitution of the waters of the localities concerned are carefully noted and in many cases tabulated. The thermal area of Baden, and the artesian wells of Atzgersdorf, have special mention and maps.

Various objects of antiquity were discovered in the course of the works. Those from an ancient cemetery (of the Bronze Period) at Leobersdorf, are particularly described and illustrated (pls. 17 and 18), by Baron von Sacken; and some pre-historic skulls, from the same place, by F. Teller. Besides the geological descriptions, sections, and maps, with which this work on the Vienna Aqueduct abounds, we must especially mention the beautiful illustrations and careful definitions of new species of fossil Mollusca and Foraminifera (pls. 16*a* and 16*b*), with which Theodor Fuchs and Felix Karrer have enriched this magnificent volume, which in every respect worthily represents the liberality of an enlightened State, and the industry and knowledge of enthusiastic and conscientious geologists, both within and without the offices of the Survey, of whom the Imperial Government may well be proud.—T.R.J.

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III.—"Neues Jahrbuch für Mineralogie, Geologie und Palæontologie," founded by K. C. von Leonhard and H. G. Bronn, continued by G. Leonhard and H. B. Geinitz. For the years 1876, 1877. 8vo. (E. Koch, Stuttgart.)

THIS well-sustained periodical continues to supply us with the results of the scientific industry of Germans and others who studiously work at rocks, minerals, and fossils in the field and in the laboratory. As usual, there are not so many memoirs devoted to physical geology and palæontology as to mineralogy and petrology; and the current correspondence shows, also, that the several fields of mineralogical study are closely cultivated by the larger number of students. But this may well be in a country largely constituted of altered and igneous rocks, and among students who have reason to look for evidence of geological history as well in the original conditions and successive changes of rock-material as in the character and position of organic remains. The valuable abstract notices of contemporaneous books and memoirs treating of geology and mineralogy are abundantly and carefully given as heretofore.

## CORRESPONDENCE.

### THE POSSIBILITY OF CHANGES OF LATITUDE.

Sir,—The question discussed in the article on Changes of Axis in the June Number of this Magazine was,—"The earth being rigid, could a deformation tilt the axis in space, or shift the position of the Poles ?" The answer was that a tilt was impossible and a shift improbable. Mr. Fisher, in the July Number, asks for a discussion of the question—"Assuming that a thin crust surrounds a fluid substratum, could then a deformation shift the crust over the nucleus ?

An obvious reply is, that if the Earth's rigidity has been proved, the discussion would be fruitless. Mr. G. H. Darwin, who has been investigating this point, concludes that the Earth is "enormously stiff" (Proc. Royal Soc., No. 188, 1878).

However, the nature and consequences of the objection to Dr. Hopkins's demonstration may be noticed. His argument was in effect that if there existed a very large fluid nucleus, since the shell would slide freely over it, the Earth's crust could not oppose to the tilting forces so great a resistance as we find from the amount of Precession that it does oppose. To this it is now answered that if the fluid nucleus be spheroidal and rotating, it would resist the tilting force which produces Precession, and the shell would not slide freely. But then would it not also resist the tilting tendency resulting from a deformation ? If Dr. Hopkins's proof from Precession collapses, does not also the supposition become untenable that a fluid nucleus would render easy a shift of the crust ? The suggestion of a fluid substratum seems to lead to the same dilemma; either the fluid could resist any shift of the crust, or it could not, and so Dr. Hopkins's disproof remains valid.

A question prior to all this is, Will a change in Latitudes give the best explanation of the phenomena ? E. Hill.

St. John's College, Cambridge, *August* 22*nd*.

### GEOLOGICAL TIME.

Sir,—The great difficulty encountered by the geologist, in reducing a section of Geological Time to years, from the want of data, is so well known, that bringing the following before your readers may be pardoned, as an attempt to measure a small section of time.

In the parish of Beith, North Aryshire, the Lower Carboniferous Limestone is extensively wrought as a surface stratum. In some quarries the limestone is preserved by a thick covering of Boulder-clay, and here the surface is ice-polished and finely striated, retaining the same features as when the ice-grinding stopped. In other quarries, where the covering is loose, the limestone is eroded into pits, swallow-holes, and crevices, many feet in thickness being often dissolved away altogether. For a long time I have been on the outlook to find a section that would give the number of feet destroyed by sub-aërial erosion since glacial action ceased, but failed until lately. It was always easy enough to know how many feet had been removed as a whole, but there was no data to show where glacial action had stopped, and sub-aërial erosion had commenced. However, a section has been laid open that gives a close approximation.

In the upper half of this limestone various bands of nodular flint occur, three of which bands are prominent; and are divided from each other by five feet of intervening limestone, and lesser flint bands. In one section, where about 20 feet of limestone had been removed by erosion, the three flint bands were found nearly entire, while the limestone was gone. It was therefore clear that all of it, from, at least, the upper flint band, had been destroyed by such sub-aërial erosion since glacial action stopped—the minimum quantity eroded cannot be less than twelve feet, probably as much as fifteen feet.

Having measured the rate of erosion for thirty years, by taking the limestone surface with a plastic substance, and replacing the loss through erosion with water, and thus calculating the loss, I find from this, that it is being denuded at the rate of $\frac{1}{16}$ of an inch in fifty years, or one foot in 9600 years. If this be anything approaching an average, it would take 115,000 years to denude twelve feet, or 144,000 to reduce fifteen feet, the probable quantity destroyed.

This gives an approximation of the time that has passed away since glacial action stopped, and sub-aërial erosion commenced. Still a considerable period may have been taken up in denuding clay left by the ice; but on this I do not enter, farther than to say that the section being on a very small plateau, on a water-shed, and I believe that very little Boulder-clay would be left upon it, and that sub-aërial erosion would commence shortly after glaciation had stopped. Robert Craig.

Langside, Beith, *Sept. 4th*, 1878.

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THE DIVINING ROD.

Sir,—The following extract from the *Marlborough Times* of Aug. 24th should possess great interest for readers of the Geol. Mag.

London, *6th Sept.*, 1878. W. H. Penning.

Search for Water.—A person from Colerne, near Bath, who professes to have the gift of divining where a spring of water is to be found by means of a small piece of white thorn of this year's growth in the shape of a V, was at Wootton Bassett the other day and operated on Mr. Hart's premises, pointing out a site for another well for his brewery—even the depth at which water would be likely to be found being designated by him. It is said that those who possess this quality are extremely few. Two or three years since a person named Weare resided in the town who used the divining rod, and who had a most implicit and sincere belief in his powers, for which he could not account, and really to a looker on the rod appeared to move quite independently of him and in fact to be beyond his control. The operator on this recent occasion stated, we believe, that he had been successful in discovering springs by this means on more than two hundred occasions without a single failure. (!)

*Yours very truly*
*John Morris.*

THE

# GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. V.

No. XI.—NOVEMBER, 1878.

## ORIGINAL ARTICLES.

### I.—Eminent Living Geologists. (No. 3.)

Professor John Morris, M.A. Cantab., F.G.S., etc.;[1]
President of the Geologists' Association.

(With a Portrait.)

THERE are left to us at the present day but a few of those naturally-gifted masters in science whose career may be fitly likened to that of the illustrious Faraday; to this type of man belongs Professor John Morris among geologists. Though occupying a modest position in society, and possessing but few of the advantages which the world offers, Professor Morris has achieved for the science of his choice a vast amount of popularity and recognition; and during a long career he has by his eloquence, his unassuming manner, and straightforward, earnest, and warm-hearted friendship, exercised a powerful influence over all with whom he has been brought in contact.

Professor Morris was born at Homerton, near London, February 19th, 1810. His father, Mr. John Morris, was a timber-merchant in the City of London, and his son is a Freeman of the Wheelwrights Company and a Freeman and Liveryman of the Turners Company, and Citizen of London, of which his father also was a Citizen. His early education was received at a private school at Clifton, near Nuneham, Berks, and afterwards at Parson's Green, Fulham. His first ideas of science were derived from some occasional lectures delivered at the Clifton School, from which he imbibed an ardent interest for Astronomy; one of his earliest papers being entitled, "A Few Observations on the Aurora Borealis visible at Kensington, on the evening of Oct. 5, 1836" (Mag. Nat. Hist., 1836, p. 574).

For many years he was engaged as a Pharmaceutical Chemist in Kensington, but although devoting part of his time to business, he was from a very early date (as his published papers demonstrate) ardently addicted to scientific pursuits, which in time engrossed all his thoughts.

So early as 1836, Mr. Morris began to collect materials for a Catalogue of British Fossils. Previous to this date, the only work available for the student in this country was "A Synoptical Table of

[1] We perhaps owe an apology to our coadjutor for publishing in our pages the above memoir, but he will, we doubt not, give us his indulgence when he knows that our imperfect record will gratify a large circle of friends who entertain for him the warmest regard.—Edit. Geol. Mag.

British Organic Remains," published in 1830, by Samuel Woodward, of Norwich. This well-known geologist, however, died in 1837, and his second son, Dr. S. P. Woodward, at that time a youthful assistant under Mr. William Lonsdale, in the Museum of the Geological Society, not attempting to bring out a new edition of his father's book, the task of supplying geologists with a work meeting this desideratum devolved upon Professor Morris.

Whilst engaged in preparing this catalogue, he published a valuable series of preliminary notes in the Magazine of Natural History for 1839. These were continued, section by section, for some time previous to the appearance of the first complete edition of the Catalogue in 1845.

In recognition of the task upon which he was engaged, the Council of the Geological Society awarded Mr. Morris the Balance of the Proceeds of the Wollaston Fund for 1842 and 1843.

The second edition of Morris's Catalogue appeared in 1854, the Council again recognizing the importance of the work by the award of the Wollaston Fund in 1850 and 1852.

We believe it is the intention of the author shortly to publish a third edition, for which he has long been engaged in accumulating materials.

This Catalogue may be placed among the most important contributions to modern geology. It is far from being a mere compilation, as every one who has worked with it can testify. Every group, every genus, every species, was made the subject of exact study, and in each department the specialist is surprised to find the advanced views of this great master in Palæontology. This work, with its wonderful accuracy in detail, has contributed largely to the elaboration of stratigraphical geology by supplying the life-data so necessary for such a task.

In the year 1855, after two geological tours through Europe, in 1853 and 1854, with Sir Roderick I. Murchison, Professor Morris was induced by that eminent geologist to offer himself as a candidate for the Chair of Geology in University College, to which he was appointed, and which he continued to hold until June, 1877,—a period of 22 years,—when the Rev. T. G. Bonney, M.A., F.R.S., was elected to succeed him. During this time Baron Goldsmid gave a small endowment to this Chair, which thenceforward bore his name. Mr. James Yates, M.A., F.R.S., also took a warm interest in Geology, and bequeathed a handsome sum for the same purpose, to be available after the death of Mrs. Yates.

But few are aware of the amount of preparation required and mental wear and tear sustained by a scientific man holding the office of Professor. During his occupation of the Chair of Geology Professor Morris delivered over 1100 lectures to his class, besides directing field-excursions and giving demonstrations in the Museum.

In addition to these lectures he delivered courses of lectures at the Royal Agricultural College, Cirencester; the Natural History Society, Newcastle; the Yorkshire Philosophical Society; the Birmingham Natural History Society; the London Institution; the Royal Institution, and the Croydon Microscopical Society. For many years he lectured at the Coal Exchange before the Coal Factors Society, on "Coal and Coal Mining"; and for two years he acted as Deputy-Woodwardian Professor of Geology in the University of Cambridge, for his old friend Professor Sedgwick. Between 1870 and 1872, and from 1877 to the present time, he has filled the office of President of the Geologists' Association, and for many years he has been accustomed to lead the country excursions of this Society in almost every district in England, ever ready in the Field as in the Class-room, to impart valuable and timely information, and elucidating the geology of each district visited with untiring energy and good will.

His printed papers are fewer in number than would have been expected from so able and experienced a geologist and palæontologist, but they are of extreme value, from the large and philosophical views which the author takes of the subjects treated on, and for the careful and extensive bibliographical references they always contain, doing full justice to his predecessors.

He has been a most constant and diligent student of the current literature of geology, ever adding new facts to his store of knowledge. But he has a strong antipathy to appear in print, and much of his knowledge would inevitably be lost to science were it not for the fact, that he is always ready to communicate information to inquirers. He is moreover so indifferent to the matter of receiving recognition, that many of his views have become common property.

We have heard one who has frequently acknowledged publicly his indebtedness to Professor Morris, say, that it was often difficult for him to distinguish what was his own work, and what he owed to Prof. Morris, seeing that the Professor so freely communicated his knowledge in conversation, that it became incorporated with the author's own store, and there being no written or printed record to appeal to, it was difficult to determine where the obligation began or ended. Many, we believe, could bear similar testimony.

But it is not alone in Geology and Palæontology that Professor Morris has proved himself an efficient master; among his varied acquirements must specially be mentioned his extensive and accurate acquaintance with Mineralogy, upon which science he gave regular lectures and demonstrations in University College. Nor is his acquaintance with practical Mining and Metallurgy less remarkable. A disinclination to engage in mercantile mining operations has, however, debarred Professor Morris from accepting many remunerative professional offers, which, "taken at the flood," might have "led on to fortune"; but Fortune's wheel was never the ambition of Professor Morris's life—his greatest happiness has been derived from traversing some well-exposed geological section, and explaining its salient features to an eager and willing class of students.

Honours, well-earned, have been bestowed upon Professor Morris, and testimonials of a more substantial nature have not been wanting to express appreciation of his services to science.

On July 14, 1870, a meeting (at which nearly a hundred gentlemen occupying prominent positions in geological science and in mining were present) was held at the Apartments of the Geological Society in Somerset House, presided over by Sir Roderick I. Murchison, Bart., K.C.B., F.R.S., to present to Professor Morris an address on vellum (indited by the facile pen of the late Prof. John Phillips, F.R.S., of Oxford), accompanied by a sum of over £600, as a testimonial of the high appreciation in which his scientific labours were held by his numerous friends.

At the Anniversary Meeting of the Geological Society, February 18th, 1876, the first award of the Lyell Medal and Fund was (by a unanimous vote of the Council) made to Professor Morris. In presenting the medal, the President, Mr. John Evans, D.C.L., LL.D., F.R.S., said, after referring in laudatory terms to Professor Morris's Catalogue and published papers on Geology:—"Your lectures have done much to spread a taste for Geology, and to enlarge the number of its students; and those who have heard you take part in our discussions must have been astonished alike at the minuteness of your knowledge of every branch of Geology and Palæontology, and at the powers of memory by which you were enabled to apply it."

On the 7th of February, 1878, Prof. Morris was admitted to the Freedom and Livery of the Turners' Company of the City of London, "in consideration of his eminence in the science that relates to the structure, composition, and distribution of the mineral substances employed in the Turners' Art."

But probably the honour of which Professor Morris feels most justly proud is that which he received on the 6th of June last, when the Senate of the University of Cambridge conferred upon him the honorary degree of Master of Arts.[1]

[1] The following is the speech delivered by the Public Orator on June 6th, 1878, in presenting John Morris, F.G.S., late Professor of Geology at University College, London, for the honorary degree of Master of Arts:—

Dignissime domine, domine Procancellarie, et tota Academia:

In his sedibus priorum sæculorum munificentia doctrinæ dedicatis atque recentioribus disciplinis melius indies accommodatis, antiqua respicimus et veneramur vetera, sed idem inter recentiora optimum quidque fovemus et nova (modo vera sint) non reformidamus. Quanto igitur cultu digna est illa præsertim scientia, quæ ipsa nuper in ordinem redacta, orbis terrarum explorat antiquitatem, quæ prioris ævi vestigia saxis impressa indagatur, quæ monumenta vetusta rupibus insculpta interpretatur, quæ illas denique rerum species quæ antiquitus vivebant cum his quæ hodie supersunt comparat. Quanta etiam laude vir hic dignus est, qui annos quadraginta, magnum vitæ spatium, illi scientiæ excolendæ feliciter impenderit; qui viginti annos inter Londinenses professoris munere egregie functus sit; qui nobis denique eo artiore vinculo sit conjunctus, quod ipse geologorum Britannicorum quotquot nunc vivunt eruditissimus, duo annos illius viri erat vicarius, qui æqualium suorum diu superstes, non recentiorum modo disciplinarum lumen sed priscæ etiam virtutis exemplar nobis præferebat, Nestor ille noster, Adamus Sedgwick.

Geologiæ quidem studiosis satis notum est hujus viri magnum illud opus, in quo tot antiquæ vitæ monumenta e rupibus effossa per seriem recensentur; sed omnes sibi eo præsertim nomine obstrinxit, quod neque laudis neque lucri avidus suos fontes omnibus patere passus est, quodque e suæ scientiæ finibus in illas artes egressus est, quæ ad communem vitæ utilitatem pertinent, illud unice verum arbitratus, scientiam artis expertem sibi soli vivere, artem scientia nixam universo generi humano magno in perpetuum esse adjumento.

Jure igitur post tot annos assiduis laboribus deditos professoris emeriti titulo inter suos ornatus est, felix laborum præteritorum memoria, felix etiam successore suo;

His own College, on his retirement from the active duties of his Chair, resolved, in appreciation of his valuable services, to retain his connexion with the Institution by appointing him "Emeritus Professor."

Professor Morris is also a Foreign Member of the Royal and Imperial Geological Institute of Vienna, of the Natural History Society of Dresden, of the Academy of Natural Sciences, Philadelphia, and of the Société Géologique du Nord.

Murchison's name is inscribed on a tablet in Bavaria's Walhalla; though the name of his early and life-long friend may never find a place there, it will ever be a household word to geologists, and his services can never be forgotten by the younger men now actively advancing the science of geology, many of whom owe so much to his teaching.

The following is a list of Professor Morris's scientific papers as far as we have been enabled to collect them:—

Observations on the Strata near Woolwich.—Mag. Nat. Hist. viii. 1835, pp. 356–367.

On a Freshwater Deposit containing Mammalian Remains recently discovered at Grays, Essex.—Mag. Nat. Hist. ix. 1836, pp. 261–264.

On some Deposits containing Mammalian Remains at Maidstone, Kent.—Mag. Nat. Hist. ix. 1836, pp. 593–597.

On some Strata usually termed Plastic Clay (1837).—Geol. Soc. Proc. ii. 1838, pp. 450–452.

On the Coast Section from White Cliff Lodge, one mile south of Ramsgate, to the Cliff's End, near the "Station Brig" in Pegwell Bay, Kent.—Geol. Soc. Proc. ii. 1838, pp. 595–596.

Remarks on the Production of Crystals.—Mag. Nat. Hist. ii. 1838, pp. 43–44.

On the Deposits containing Carnivora and other Mammalia in the Valley of the Thames.—Mag. Nat. Hist. ii. 1838, pp. 539–548.

A Systematic Catalogue of the Fossil Plants of Britain.—Mag. Nat. Hist. iii. 1839, pp. 452–457, 543–548, iv. pp. 75–80, 179–183.

Remarks upon the Recent and Fossil CYCADEÆ.—Ann. Nat. Hist. vii. 1841, pp. 110–120.

On the Occurrence of the Genus *Pollicipes* in the Oxford Clay.—Ann. Nat. Hist. xv. 1845, pp. 30–31.

Description of some New Species of the Genus *Ancyloceras*.—Ann. Nat. Hist. xv. 1845, pp. 31–34.

On the sub-division of the Genus *Terebratula*.—Geol. Soc. Journ. ii. 1846, pp. 382–389.

Description of a New Species of *Nautilus* from the Lower Greensand of the Isle of Wight.—Ann. Nat. Hist. i. 1848, pp. 106–107.

Observations on Mr. Hancock's paper on Excavating Sponges.—Ann. Nat. Hist. iv. 1849, pp. 239–242.

Note on the Genus *Siphonotreta*, with a description of a new Species (*S. Anglica*). Ann. Nat. Hist. iv. 1849, pp. 315–321; Brit. Assoc. Rep. 1849 (pt. 2), pp. 57–58.

On *Neritoma*, a Fossil Genus of Gasteropodous Molluscs allied to *Nerita*.—Geol. Soc. Journ. v. 1849, pp. 332–335.

On the Occurrence of Mammalian Remains at Brentford.—Geol. Soc. Journ. vi. 1850, pp. 201–204.

jure a nobis artium magister hodie salutatus, quasi ex alto mari in portum placidum vectus hac saltem laureola nunc demum coronatur,

ceu pressæ cum jam portum tetigere carinæ
puppibus et læti nautæ imposuere coronas.

Ceterum nobis vix necesse est coram illo plura dicere, cui lapides quoque muti loquuntur; quod si talis viri laudes prorsus tacuissemus, prope ipsa saxa (nisi fallor) indignabunda reclamare voluissent.

Duco ad vos JOHANNEM MORRIS.

Palæontological Notes.—Ann. Nat. Hist. viii. 1851, pp. 85–90.

Description of a Species of Belemnite (*Belemnites Bouchardi*), with Observations on *Aptychus*.—Ann. Nat. Hist. x. 1852, pp. 355–356.

Description of some Fossil Shells from the Lower Thanet Sands (*Sanguinolaria Edwardsii; Panopæa granulata; Pholadomya Koninckii*).—Geol. Soc. Journ. viii. 1852, pp. 264–268.

On some Sections of the Oolitic District of Lincolnshire.—Geol. Soc. Journ. ix. 1852, pp. 317–344.

Notes on some Miscellaneous Fossils from the "Woolwich" and "Reading Series."—Geol. Soc. Journ. x. 1854, pp. 157–160.

On the Occurrence of Allophane at Charlton, Kent.—Geol. Soc. Journ. xiii. 1857, pp. 13–17.

British Fossils stratigraphically arraged.—"Geologist," 1858, pp. 138–142, 189–194, 233–238, 279-286, 319–324. Part I. Silurian Fossils.

Description of the May Hill Limestone.—Malvern Nat. Field Club, Trans. ii. 1858, pp. 4–5.

On a Species of Fern from the Coal-measures of Worcestershire [1858]—Geol. Soc. Journ. xv. 1859, pp. 80-84.

On Coal; its Geological and Geographical Position.—Geol. Assoc. Proc. i. 1859-63, pp. 170–192.

On Coal-plants.—Geol. Assoc. Proc. i. 1859-63, pp. 289–301.

A Catalogue of British Fossils; comprising all the Genera and Species hitherto described, etc. London, 1843. 8vo.

Ditto. Second edition, 1854. 8vo. pp. 380.

Descriptions of Fossils from New South Wales and Van Diemen's Land, in Count P. E. de Strzelecki's Physical Description of New South Wales and Van Diemen's Land. London, 1845. 8vo. pp. 462.

On the Occurrence of Grey-Wethers at Grays, Essex.—Geol. Mag. 1867, Vol. IV. p. 63.

On the Ferruginous Sands of Buckinghamshire.—Geol. Mag. 1867, Vol. IV. p. 456.

Geological Excursion to Bath.—Geol. Mag. 1868, Vol. V. p. 233.

Notes on the Gravel Beds at Finchley.—Geol. Mag. 1868, Vol. V. p. 411.

On Organic Remains in the Somersetshire Coal-field, 1868, Vol. V. p. 356.

Geological Notes on parts of Northampton- and Lincolnshires.—Geol. Mag. 1869, Vol. VI. p. 99.

On the Genus *Æchmodus* from the Lias of Lyme Regis.—Geol. Mag. 1869, Vol. VI. p. 337.

"Gems and Precious Stones of Great Britian."—Popular Science Review, vol. vii. 1868, p. 123, pl. xxiii.

"On the Fossil Man at Mentone."—Pop. Sci. Rev. vol. xi. p. 283.

"The Cretaceous Flora."—Pop. Sci. Rev. vol. xv. pp. 46–59.

The Lead-bearing Districts of the North of England.—Proc. Geol. Assoc. 1869; Geol. Mag. Vol. VI. p. 317.

On the Occurrence of Boring Mollusca in the Oolitic Rocks.—Geol. Mag. 1875, Dec. II. Vol. II. p. 267.

On the Geology of Croydon.—Proc. Microscop. Club, Croydon, 1875.

Description of the Fossil Plants, in Professor J. Prestwich's Memoir "On the Geology of the Coalbrook Dale Coal-field."—Trans. Geol. Soc. 1840, 2 series, vol. v.

On the Physical Structure of the London Basin.—Proc. Watford Nat. Hist. Soc. 1876, vol. i. p. 89.

The Geology of the District around Aylesbury.—Bucks Archæological Soc. August, 1862.

The Geology of Hartwell.—Lond. Univ. Mag. June, 1856.

Address to the Geologists' Association.—Proc. Geol. Assoc. 1877, vol. v. pp. 191–230.

Geological Diagrams—Reynolds, London, new edition, 1878.

## Joint Papers.

Morris, John, and Thos. Davidson. Descriptions of some Species of Brachiopoda (*Leptæna liasina*, *L. Bouchardi*, *L. Pearcei*, *Terebratula rugulosa*, *T. spinulosa*, etc.)—Ann. Nat. Hist. xx. 1847, pp. 250–257.

Morris, John, and L. L. Boscawen Ibbetson. Notice of the Geology of the Neighbourhood of Stamford and Peterborough.—Brit. Assoc. Rep. 1848, pp. 127–131; Roma Corrisp. Scient. I. 1848, p. 33.

Morris, John, and J. Lycett. On *Pachyrisma*, a Fossil Genus of Lamellibranchiate Conchifera.—Geol. Soc. Journ. vi. 1849, pp. 399–402.

Morris, John, and John Lycett. A Monograph of the Mollusca from the Great Oolite, chiefly from Minchinhampton and the Coast of Yorkshire.

Part I. Univalves, 1850, Pal. Soc. Mon. 4to. pp. 130 and 15 plates.
Part II. Bivalves, 1853, „ „ „ pp. 148 and 15 plates.

Morris, John, and R. I. Murchison. On the Palæozoic and their associated Rocks of the Thüringerwald and the Harz.—Geol. Soc. Journ. xi. 1855, pp. 409–450.

Morris, John, and J. Prestwich. On the Wealden Strata exposed by the Tunbridge Wells Railway.—Geol. Soc. Journ. ii. 1846, pp. 397–405.

Morris, John, and Geo. E. Roberts. On the Carboniferous Limestone of Oreton and Farlow, Clee Hills, Shropshire.—Geol. Soc. Journ. xviii. 1862, p. 94–102.

Morris, John, and Daniel Sharpe. Description of eight Species of Brachiopodous Shells from the Palæozoic Rocks of the Falkland Islands.—Geol. Soc. Journ. ii. 1846, pp. 274–278.

Morris, John, and Thomas Oldham. On the Fossil Flora of the Rajmahal Hills, Bengal.—Palæontologia Indica, Parts 1–6, 4to.

Morris, John, and Prof. T. Rupert Jones. Geology. First Series. Heads of Lectures on Geology and Mineralogy, 1866–70. 8vo. pp. 84. London, 1870. Van Voorst.

*Note.*—Probably many imperfections will be detected in this list: many Notices and Reviews, written by Prof. Morris, often replete with original observations, have appeared in these pages anonymously, or only with the initials "J. M." appended to them.—Edit. Geol. Mag.

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## II.—The General History of the Cephalopoda, Recent and Fossil.[1]

By Miss Agnes Crane.

Many of the living forms of Cephalopodous molluscs are now, thanks to the Brighton Aquarium, familiar to us all; and, as the habits and characteristics of the squids, octopods, and cuttles have been duly recorded by Mr. Henry Lee in his amusing book on "The Octopus,"[2] published in 1875, I shall here restrict myself to those points in the structure of the living forms which bear upon the history of the class as a whole, giving merely those anatomical details which are absolutely indispensable for a right comprehension of the nature and affinities of the numerous fossil and extinct members of the order. I may, however, observe, *en passant*, that the existence of a certain sub-stratum of truth in the old stories of giant Cephalopods was ably proved by Mr. Saville Kent, in the "Popular Science Review," for 1874, and that specimens have been more recently cast ashore in Trinity and Logie Bays, on the coast of Newfoundland, that may fairly claim to be of enormous dimensions. Thus, in a truly formidable calamary, or squid, the tentacular arms measured 30 feet, the largest suckers being one inch in diameter, the shorter (or pedal) arms were 11 feet long, and the body was 10 feet. Professor Verrill has also described a huge cuttle, estimating the total length at 40 feet, the large tentacles were 26 feet long, with a maximum circum-

[1] This paper, originally read before the Brighton and Sussex Natural History Society, September 12, 1878, has since been carefully revised and augmented both by the Authoress and the Editor.

[2] "The Octopus." Henry Lee. London, 1875.

ference of 16 inches at their union to the body. A new genus of calamary, allied to the *Architeuthis* of Steenstrup, with arms measuring over 23 feet, was discovered on the island of St. Paul, in the Indian Ocean, by M. Charles Vélain, the naturalist attached to the French Expedition for the observation of the transit of Venus, at that station.[1] The size attained by some of the fossil species will be noted in the sequel.

The *Cephalopoda*[2] are more highly organized than any other members of the sub-kingdom Mollusca; and, consequently, rank at the summit of that great natural division of the animal kingdom, comprising the invertebrated animals. The technical name of this important group of molluscs describes the position of their locomotive and prehensile organs, which are attached in a circle round the mouth. The brain, eyes, heart, and lungs, are well developed. The *Cephalopods* are all inhabitants of the sea, and are almost universally distributed in the existing oceans. The geological range of the class is also great, for they occur, more or less abundantly, in a fossil state in all the marine deposits, ranging from the Upper Cambrian formation upwards throughout the whole sequence of geological strata. They are divided into two groups, a classification (first proposed by Prof. Owen)[3] based on the respiratory system. The more lowly organized tetrabranchiate, or four-gilled, Cephalopods are characterized by the possession of a many-chambered external shell, and the absence of an ink-bag. Our knowledge of the anatomy of this once dominant class, so abundantly represented in the seas of the Palæozoic and Secondary periods, is founded solely on the structure of the Pearly Nautilus, the only member of the order surviving in the existing oceans. Dead shells of this genus, of which there are at most three species, are a common object in our museums, but the animal inhabiting that wondrous dwelling has but rarely been obtained. It was, however, certainly known to Aristotle, but no further observations were recorded until those of the Dutch naturalist Rumphius in 1705. It long headed the list of rarities desired by Cuvier, but that illustrious naturalist unfortunately died three days before the publication, in 1832, of Professor Owen's elaborate memoir[4] based on the study of a specimen, caught by his former pupil, Dr. Bennett, when drifting on the surface of the South Pacific Ocean, off one of the New Hebrides Islands. A living specimen was also *dredged* in 300 fathoms during the cruise of the "Challenger," near the Windward Islands.[5] The shell of the Nautilus is divided by shelly partitions or septa into many cells or chambers, which are connected by a siphuncle, or tube, centrally situated. The animal inhabits the last and most spacious chamber, and has the power of forming a fresh one when necessary. Each chamber was thus occupied in

[1] Remarques au sujet de la faune des îles Saint Paul et Amsterdam, etc. Charles Vélain, Paris, 1878. 8vo.

[2] "Head-footed Mollusca," from κεφαλή 'head' and πους 'foot.'

[3] See also Baron Cuvier's Anatomie des Mollusques for details of the structure of the *Dibranchiata*.

[4] On the Pearly Nautilus. Richard Owen. London, 1832. 4to.

[5] Proceedings Royal Society, 1874.

succession. The functions of the siphuncle have been variously interpreted. First by Dr. Hooke, in 1696, as serving to admit water to the aerial chambers when the animal was desirous of sinking to the bottom of the sea. The difficulty attendant on the expulsion of the water, and the re-admission of air in the ocean depths, was solved by supposing the Nautilus to be gifted with the power of secreting an aerial fluid at will. But, the fact that the siphuncle only pierces the septa, and has no connexion with the aerial chambers, renders this theory unacceptable. Dr. Buckland [1] held that the siphuncle communicated with the pericardium, and received a fluid contained therein when the creature was desirous of altering the specific gravity of the shell in order to sink beneath the waves. According to Prof. Keferstein,[2] of Göttingen, the Nautilus periodically secretes an aerial gas from the base of its mantle, which is prevented from communicating with the sea water by a special structure, and the gas thus generated causes the animal to move upwards in its shell, and supports its weight when the construction of a new chamber is necessary, the shell muscles advancing gradually and not being abruptly ruptured as supposed by D'Orbigny. The air thus secreted is then inclosed by a nacreous deposit from the mantle, and a new aerial chamber is completed. M. Barrande, who has treated the subject of the functions of the siphuncle, and the progression of the mollusc in the water, in a most impartial and exhaustive manner, in his magnificent memoirs on the Palæozoic Cephalopoda,[3] considers the enforced periodic rests, imposed on the creature by Prof. Keferstein immediately after the formation of a new chamber, to be irreconcilable with the free liberty of movement enjoyed by the other members of the cephalopodous class, and obviates this necessity by assuming that the surface of the mantle endowed with the power of exhaling the aerial gas is also capable of re-absorbing it, and thus the ascent and descent of the Nautilus in the water is entirely under the control of the will of the animal.

Some authors, however, maintain that the movement of the animal in or out of the shell was sufficient to facilitate its progression in the water, and regard the siphuncle as serving either to attach the animal to its protective covering, or to insure the repair and vitality of the whole of the shell, and a few, as destined merely for the reception and development of the eggs. Others believe that the Nautili live habitually at the bottom of the sea, being only *driven to the surface* during storms, or when in a dying condition; an argument that is supported by the fact that their chief food appears to consist of the hairy non-swimming brachyurous crabs which live always on the ocean floor. Among those holding this view, and therefore recognizing no necessity for the ingenious theories of Professor Keferstein, and M. Barrande, Dr. Henry Woodward deserves especial

[1] Bridgewater Treatise. Geology. 1836.

[2] Bronn's Klassen u. Ordnungen d. Thierreich, III., Malacozoa, 2te Abtheil., p. 1344.

[3] Système Silurien de la Bohême, vol. ii. texte, v. pp. 962 and 1235. Joachim Barrande. Prague, 1877.

mention [1] for the lucidity with which he has expressed his opinions in an interesting paper "On the Structure of Camerated Shells," published in the *Popular Science Review* in 1872.[2] He there contends that the Nautili do not swim, but are sluggish crawling animals, and bottom-feeders, and consequently do not require buoyant shells furnished with air-cells, if indeed the so-called aerial chambers could act as such, liable as they would be to become partially filled with sea-water, which must undoubtedly penetrate by endosmosis through the pores. He denies the possibility of the siphuncle maintaining the vitality of the shell, because it is certainly a non-vascular structure, and there is no connexion between it and those portions of the shell which lie in contact with the mantle, the sole shell-secreting organ in the Mollusca. The divisional septa are regarded as indications of periodical, natural, and reproductive growth,[3] and as possibly serving "to shut off the discarded and untenantable" parts of the shell; and he regards the siphuncle as the remnant of a rudimentary or embryonic organ, which attached the animal to the shell in its earliest stages, a function that would well accord with the existence of enormous siphuncles in some of the most ancient fossil forms when the embryonic conditions were probably retained during life. A somewhat similar camerated, or chambered, structure exists in many Gasteropods (*Helix*, *Euomphalus*, etc.), and also in aged oysters and other bivalves, while in some corals a central tube is visible with radiating septa or partitions. Dr. Woodward therefore does not admit the organization of the chambered shells of the Cephalopoda to be an entirely exclusive structure, but considers it as only a modification of the shell-structure found in other mollusca.

The parrot-like jaws of the recent Nautilus are blunt and calcareous at their tips, and similar beaks, called *Rhyncholites*, formerly regarded as those of fossil birds, occur in all strata associated with the fossil Tetrabranchs, and are now referred to extinct species. "The digitations, or lateral processes," thirty-eight in number, are retractible into eight sheaths, corresponding to the eight ordinary arms of the cuttles. The two dorsal arms unite to form the hood which serves to close the opening at the mouth of the shell. All these numerous arms are unprovided with suckers. There are four gills or branchiæ,

[1] My attention has been called by Dr. H. Woodward to a valuable contribution to this subject by Professor H. Govier Seeley, F.G.S., in the report of the British Association for the Advancement of Science, 1864, Bath, Transactions of Sections, p. 100, entitled "On the Significance of the Septa and Siphuncles of Cephalopod Shells;" see also the Quart. Journal of Science, October, 1864.

[2] British Association Reports, Liverpool, 1870, Transactions of Sections. *Popular Science Review*, 1872. See also Note at the end of the present article, p. 499.

[3] On my recently calling the attention of Prof. James Hall, LL.D., to these views as to the significance of the septa in the chambered Cephalopods, that distinguished American palæontologist, whilst fully admitting the force of the hypothesis of their production by those natural causes, suggested that the fact of the septa being composed of three distinct layers of shell-substance, viz. an outer nacreous one, an inner porcellanous one, and a third external nacreous deposit, could hardly thus be accounted for. As both the external surfaces were smoothed and polished, apparently by the application of some part of the body of the animal, it was further difficult to conceive how access was obtained to the outer surface of the last formed septa after the animal had once partitioned off its body in the manner supposed.

and the circulatory and respiratory apparatus is less highly developed than in the succeeding dibranchiate forms. The digestive system is, however, similar, consisting of a crop and a gizzard, resembling that of the common fowl. The curious fossil plates called *Aptychi*, now known as the opercula, or defensive covering to the aperture of the body-chamber of the shell, of the extinct family of *Ammonites*, were at one time considered to be the fossil gizzards of *Cephalopods*. They were also described as bivalve shells, but the discovery of an *Ammonite* in which they were revealed *in situ*, filling up the opening of the shell, sufficiently indicated their true nature.[1] The Nautilus carries its shell snail-fashion when crawling, by means of its many feet, head-downwards, at the bottom of the sea. The specimen kept alive for a few hours on board the Challenger, propelled itself backwards and forwards by the expulsion of water from the funnel, after the fashion of the Octopods.

The Nautilus is the sole "persistent type" among all the varied forms of the *Cephalopods*, that is to say, it forms the only genus which has been represented in all geological ages since the deposition of the primæval Silurian rocks. The genus underwent some strange vicissitudes. One of the twelve primitive cephalopodous types, it was represented by twelve species in the Lower Silurian seas, these decreased to ten in the succeeding Upper Silurian epoch, and to eight in the overlying Devonian. No less than eighty-four species swarmed in the Carboniferous seas, evidently most favourable to their development. Of these, all save five were extinguished during the deposition of the Permian rocks, a period of the world's history when life was, comparatively speaking, not so abundant in the waters of the earth; or when perhaps (speaking more correctly) the sedimentary deposits were less favourable to the preservation of the organisms entombed within their now highly-altered strata. Forty-seven species re-appeared in the Triassic and Jurassic formations, while during the Cretaceous epoch the Nautili attained their second maximum point of development, 63 species being recorded from those deposits. These again declined to 15 in the Tertiaries, and to three[2] in the existing oceans.[3] Truly of most ancient lineage, a contemporary of some of the earliest forms of life, the Nautilus has been a witness of many successive changes in the physical features of the world, and surviving the unknown causes so fatal to all the other members of its race at the close of the Cretaceous period, has held its own in the battle of life, and now forms one of the most curious and interesting of the living wonders of the deep.

Twenty-five genera of fossil Tetrabranchiates were represented in the Palæozoic seas. Twelve of these were primitive cosmopolitan types, and occur in beds at the base of the Lower Silurian formation

[1] See paper by Dr. S. P. Woodward on an Ammonite from the Inferior Oolite with the operculum *in situ*, "Geologist," vol. iii. 1860, p. 328.

[2] As the broad-mouthed *Nautilus pompilius* is the female, it is highly probable that the *N. umbilicatus* is the male of the same species. Among Ammonites both tumid and flattened forms have been observed in most species. See "Woodward's Manual of the Mollusca," p. 83.

[3] Céphalopodes, Etudes Générales. J. Barrande. 1877. Table 1, p. 84.

in all parts of the world. These primitive types are, however, widely divergent, comprising the *Nautilus*, the curved *Cyrtoceras*, the straight-shelled *Orthoceras* and *Endoceras*, the club-shaped *Gomphoceras*, and the simply-coiled *Lituites*. Some of these generic forms enjoyed a very brief existence, and after becoming specifically numerous, died out almost as suddenly as they appeared. The *Orthoceratites* were certainly, among the mollusca, the giant rulers of those ancient seas, and many attained large dimensions, measuring ten or twelve feet in length. One American species, truly an *Orthoceras Titan*,[1] estimated by Dr. J. S. Newberry as weighing "some tons," must have fairly rivalled the fabled living "Kraken," endowed by the older naturalists with the power of sinking a ship seized in the clutches of their snake-like arms. The shell of *Orthoceras* is straight, and the septa of the vertical chambers, pierced by a nearly central siphuncle, are simple at their edges, like those of Nautilus. The last chamber seems comparatively small for the occupation of an animal capable of sustaining and directing such an enormous shell, and it has been suggested that the shell was internal as in the living cuttles and the extinct *Belemnites*. This view, which is not generally entertained, was considered by the late Dr. S. P. Woodward[2] to be untenable on the grounds that in some specimens the exterior colour-bands appear to have been preserved on the outer surface of the shell, and thus prove it to have occupied an external position. There were 260[3] species of *Orthoceras* in the Lower Silurian rocks, a number which increased to 626 in the Upper Silurian seas, when the life-conditions were very suitable. They declined rapidly in the succeeding Palæozoic epochs, and were represented only by fourteen dwarfed forms in the Triassic deposits, the dawn of the great Secondary life-period of geologic history. In the curved and elegant *Cyrtoceras*, the increase from 90 *specific* forms in the Lower Silurian rocks to 299 in the upper beds is even still more remarkable, and affords an idea of the enormous duration of time that must have elapsed during the deposition of that early fossiliferous series. Only one species of the genus survived in the Permian era.

In the coiled *Goniatites* of the Upper Silurian beds we have the first indications of that ornamentation of the edges of the chambers, which subsequently became such a marked and beautiful feature in the numerous family of the *Ammonites* which ranged in Europe from the Trias to the Chalk, and of which there are several hundred known species. Some specimens found in the Carboniferous rocks of India must have been contemporary with the *Goniatites*, a fact that is not without interest when the theory of the evolution of the class comes to be considered. *Ammonites* have also been obtained from the Oolitic deposits in the passes of the Himalayas at a height of over 16,000 feet above the level of the sea, and afford a striking instance of variations in the physical configuration of the world, for it is obvious that when they lived and died the Himalayas were not, and similar palæontological data prove that those snow-clad moun-

[1] State Reports of the Geology of Ohio.—Palæontology, vol. i. p. 263.
[2] Manual of the Mollusca. 2nd edition, 1868. S. P. Woodward.
[3] Barrande, ibid.

tain peaks were not upheaved until a comparatively recent period. The body-chamber of the *Ammonite* seemed to be so small in proportion to that of the Nautilus that Dr. Gray[2] was led to conclude that the shell was not inhabited by the animal, but was *internal,* resembling that of the existing *Spirula.* The fact is, the last chamber is rarely preserved in an unbroken condition, there being, of course, *no septa* to strengthen the walls of this last part of the shell, which is in consequence usually crushed and flattened. But occasionally the interior, discoloured by the decomposition of animal matter, furnishes indisputable evidence that the creature inhabited it during life, and was buried in it after death.[3] The siphuncle is next the keel, and the edges of the septa, where they unite with the shell-wall, are beautifully foliated in various patterns peculiar to the respective groups. This foliation is very remarkable in some species, and is visible in all when the outer surface of the shell is removed. As in all these fossil genera, the classification of the *Ammonitidæ* is necessarily based on the characters of the shell alone. There are sixteen type-groups, each of which characterizes a certain horizon, and the presence of a member of a group in any deposit denotes its position in the geological series. In the Liassic formation even species of Ammonites are said to be restricted to a certain horizon, and never to occur out of it;[4] a knowledge of the limits of these groups is therefore of great service to the seekers for any of the rich industrial products for which that formation is so noted. Thus, although the rich ironstone bands occur only in the zone of *Ammonites spinatus,* many useless searches for iron were formerly made in the beds characterized by *Ammonites annulatus,* the outward appearances of the strata being identical. Again, the familiar *Ammonites communis* is found only in the alum shale, and *Ammonites serpentinus* in the jet-bearing rocks. The numerous representatives of this most extensive genus were originally grouped in sections or families, a very artificial mode of division. The far more consistent method, first inaugurated by Continental palæontologists, of assigning generic names to the various series of characteristic species, is now, however, becoming generally adopted in England. The interesting family of the *Ammonitidæ* reached its maximum in the Jurassic epoch; it was, however, numerously represented in the Cretaceous seas, and some specimens attained large size, measuring over three feet in diameter. On their total extinction at the close of the Chalk period, they can by no means be regarded as an effete race, for several varied types, such as *Turrilites, Scaphites,* and *Hamites,* etc., made their appearance in the Cretaceous epoch, but, enjoying a very restricted range, died out

[1] Post-Eocene Period.

[2] Ann. and Mag. Natural History, 1845, vol. xv. pp. 257 and 444.

[3] Specimens of *A. heterophyllus* and of *A. perarmatus,* and many other species, preserved in the British Museum, show the body-chamber to have been of very large extent.—H. W.

[4] This conclusion, however, so contrary to all known zoological laws regulating the distribution of life in time and space, may well be received with great caution, even when given on high authority and apparently borne out by many and widespread facts.—H. W.

almost as suddenly as some of the more ancient members of that tetrabranchiate group, of which they were nearly the last representatives.

In the more highly organized, but, geologically speaking, modern class of *dibranchiate*, or two-gilled Cephalopods, the shell is internal, and rudimentary in the *Octopoda*, either horny as in the squids, or calcareous and laminated as in the cuttles. In these "naked" forms, respiration is effected by means of two gills instead of four. The *dibranchs* are active free-swimming animals possessing super-added branchial hearts, and, therefore, a more complex and vigorous circulatory system, which gives them increased powers of locomotion. The ink-bag is always present more or less developed, and its preservation in a fossil state is regarded by Professor Owen as certain evidence of the existence of forms unprotected by an external defensive shell. The parrot-like mandibles are horny, and are quite hidden from view at the base of the web uniting the arms to the body. In the Octopoda, or eight-armed species, it is important to remember, they form the only portions of the animal susceptible of preservation in sedimentary strata. In the cuttles, the two long additional tentacular arms are retractible, and are only extended when the animal is capturing its living prey, or in the act of dissolution. In some species of the Calamaries or squids, they are rendered still more formidable weapons of offence and defence by the addition of a double series of horny hooks attached to the club-like ends of the tentacles. In the anomalous genus *Argonaut*, or Paper Nautilus, the *Nautilus primus* of Aristotle, the position of the one-celled shell is *external*.[1] It is, however, believed to be peculiar to the female, and, not being attached to the animal by shell-muscles, is considered as serving more probably for the protection and incubation of the eggs. Two species of this genus occur, fossil, in later Tertiary deposits. In *Spirula*, again, the shell, though internal, is many-chambered and siphunculated. Dead shells of this genus abound in the warmer seas, but the animal has been but rarely obtained, except in a more or less fragmentary condition. Specimens were fortunately procured during the cruise of the "Challenger," and will receive a detailed description from Professor Huxley. *Spirula* is an exceptional form that may possibly be found to possess characters uniting the dibranchiates to their more lowly organized predecessors, and will, at any rate, throw additional light on the structure of the fossil members of the order to which, from the presence of an ink-bag, it was originally referred by Professor Owen.[2]

Of the existence of this highly-organized class of Cephalopods prior to the Secondary period, we have purely negative evidence. If any of their forms inhabited the Palæozoic seas, they have left no certain traces for the instruction of the naturalist. The earliest

[1] This must be understood in a modified sense. The fact is the two broadly-expanded (shell-secreting?) dorsal arms (figured as "sails" in the allegorical representations of the "Argonaut") *closely envelope* the shell on either side, so that in the lifetime of the animal the shell is almost, if not wholly, concealed; whereas the animal can but partially conceal itself within the shell.—H. W.

[2] Voyage of H.M.S. Samarang (Zoology), pp. 6–17, pl. 4. 4to. 1848.

known appearance of the group is in the Trias, when the extinct family of *Belemnites,* which subsequently became such a marked feature in the Jurassic seas, was first represented by a few forms which were the contemporaries of the last surviving members of the once powerful race of *Orthocerata.* These apparently primitive *Belemnites* lived in the shallow seas in which were deposited the St. Cassian beds of geologists (situated in the Austrian Alps), so famous for the admixture of Palæozoic and Secondary types, and as serving to indicate the absolute continuity of the geological series. Of the now numerous family of Octopods, we have no trace in a fossil state, although, as already stated, their horny mandibles are susceptible of preservation. Beaks, of a similar horny texture, occur in rocks of Secondary and Tertiary age; but their size and shape is suggestive of their belonging either to the fossil cuttles and squids, or to their extinct allies, the *Belemnitidæ,* whose remains are associated with them in the same strata. The inference that giant naked Cephalopods existed in the Palæozoic seas with calcareous jaws, is, of course, a purely speculative one. The distribution of the true cuttles (the *Sepiadæ*) is universal in the existing oceans. Remains of the family are preserved in the Lias Oxford clay, other Oolitic deposits, and in the Tertiaries. The living *Teuthidæ,* the Calamaries, or squids, are also widely distributed. They are found fossil in the Upper Liassic, Oolitic, Cretaceous, and Tertiary formations.

The history of the organization of the fossils comprising the remaining dibranchiate family, the now wholly extinct *Belemnitidæ,* was long involved in mystery. Specimens of the remarkable genus, *Belemnoteuthis,* were preserved in a marvellously perfect manner in the Oxford clay, at Chippenham, in Wiltshire, the mantle, fins, eye sockets, beaks, and tentacles being all entombed in juxtaposition. The internal, vertically chambered, partly calcareous skeleton, is attached to a horny pointed guard, resembling the familiar "thunder-bolt" of our childhood. The animal was indeed first described by Professor Owen,[1] in 1844, as that of the true *Belemnite;* but it is now considered as being more allied to the Calamaries, especially to the genus *Onychoteuthis,* now existing in the Indian Ocean, the tentacles in both forms being armed with a double series of formidable horny hooks. Dr. Mantell[2] first showed that this curious fossil possessed some points of internal structure that could not have been associated with, or fitted into, the horny guards forming the apex of the chambered skeleton of the *Belemnite,* and the affinities of *Belemnoteuthis* were then recognized as being with the Calamaries; but Professor Owen still maintains that it illustrates the close connexion existing between the two groups of organisms. Indeed, the *Belemnitidæ* may be fairly regarded merely as an extinct branch of the Squid family. The presence of an ink-bag and ten arms in the animal to which the appendage known as the *Belemnite* belonged, was first suspected by Dr. Buckland;[3]

[1] Phil. Trans., 1844. On the animal of Belemnite.
[2] Phil. Trans., 1848 and 1850. [3] Bridgewater Treatise, 1836.

but, it was not until the description by Professor Huxley[1] of an interesting fossil from the *Ammonites obtusus* zone of the Lower Lias, near Charmouth, in Dorset, in which the parts of the internal structure known respectively as the pointed guard, the phragmocone, or chambered portion, and the nacreous pro-ostracum were found *in situ* with indications of an ink-bag, and tentacles armed with horny hooks one-sixth of an inch long, that the anatomical details of the genus *Belemnites*, as distinct from that of *Belemnoteuthis*, were at length finally and satisfactorily established.

So far, it is obvious, that there are two distinct types of Cephalopods. One, with an external chambered shell, simply constructed eyes, four gills, no suckers, and no ink-bag, very abundantly represented in the ancient seas, and those of the middle geologic epoch, and of which one genus only survives at the present day. The other, possessing an internal shell, two gills, tentacles armed with suckers, and sometimes hooks, an ink-bag, and perfect organs of vision, appeared first in the Triassic period, was largely developed in the Jurassic seas, and predominates in the existing oceans. When the ancient tetrabranchs were the rulers of the seas during the "reign of Molluscs," the Gasteropodous class was represented chiefly by the lowest organized herbivorous forms, the carnivorous snails, etc., not making their appearance until the Secondary epoch, when they became the contemporaries of the dibranchiate Cephalopods. In past ages the Tetrabranchs probably performed the office of restricting the undue increase of the co-existing Crustaceans and Mollusca, and possibly their own numerical abundance was in turn influenced by the appearance and development in Devonian and Carboniferous times of the formidable armour-plated fishes. In the Secondary period, the dibranchiates served as food for the extinct Enaliosaurians, or Sea-lizards, as in the present day, for the predacious fishes, penguins, and other sea-birds, some species of cetacea, and, in a few countries, even for man.[2] Thus, both groups fulfilled their functions in the economy of nature, and the balance of power was maintained. Of all the vast families of *Nautilidæ*, *Goniatidæ*, and *Ammonitidæ*, the long-lived *Nautilus* alone survives. Whether the increase of the more highly organized group affected the further development of the lower forms, cannot positively be affirmed; but it is certain that the causes which led to the extinction of the *Tetrabranchiates* (with the exception aforesaid), at the close of the Cretaceous epoch, had no influence whatever upon the more highly organized forms, which persisted through the Tertiaries, and abound in the existing oceans.

There remains but to consider the evidence of the Cephalopods with regard to the theory of Evolution, a subject on which opinions are naturally very diverse. The existence of a certain amount of

[1] Mem. Geological Survey, Monograph II., 1864.

[2] Octopods, cuttles, and squids were highly esteemed as epicurean dainties in ancient Rome, and the former are now largely consumed as food in the sea-coast towns of France and Italy. While according to Dr. Macdonald the Pearly Nautilus is regarded as an agreeable viand by the inhabitants of the Feejee Islands!

progressive development in the history of the class, so far as relates to the first appearance of the lowest forms in the primeval oceans, and to the succession of that more highly developed group, which mainly represents the order at the present day, cannot reasonably be denied. The occurrence of certain comprehensive types, uniting characters which subsequently became distinctive peculiarities of diverse genera, must also be admitted. Thus, as Professor Owen[1] has shown, in the *Belemnitidæ* are united the internal chambered and siphunculated structure retained solely in the existing *Spirula*, while the horny armature of the tentacles is at present restricted to one genus of the living Calamaries, but he does not fail to point out that the perfect preservation of the fossil forms has revealed the fact that the armature of the Secondary Cephalopods was as highly organised as that of any of the species inhabiting our present seas, and is not, therefore, indicative of any great rate of progression, notwithstanding the enormous intervals of time that must have elapsed between the Secondary and the Recent period. Again, according to Sir Charles Lyell,[2] "The rate of progression has been slow indeed, if the only step realized between the Lower Silurian and modern times can be expressed by the passage from the tetrabranchiate to the dibranchiate Cephalopod, a rate of progress that might require a course of ages anterior to the Silurian epoch, as great as that which has since elapsed in order to bring about a gradual evolution from a Bryozoon to an Orthoceras." The important testimony of M. Joachim Barrande,[3] founded on a special and extended survey of more than 2,500 Palæozoic species, is also directly opposed to the theory that one form has been evolved from another. That illustrious palæontologist, who, from his vast labours among the Palæozoic rocks of Central Germany, may be fitly entitled the "Murchison of Bohemia," contends that the recent Nautilus possesses the same essential characters as the earliest known forms so universally distributed at the base of the Lower Silurian formation,[4] that a detailed examination of the structure of the Tetrabranchiate Cephalopods, whether as applied to the position and diameter of the syphon, the size, composition and ornamentative characters of the shell, furnishes no evidence in support of the theories of descent by modification, natural selection, or the survival of the fittest; and further, that the stability of generic types, and the distribution of the group in geological time, is equally opposed to them. The complex forms, moreover, often precede the simpler ones, while those which appear to be intermediate follow the genera which they might otherwise be supposed to connect. It must, however, be noted that the arguments as to the relative simplicity, or complexity, of structure, are founded

[1] Phil. Trans., 1844.

[2] Principles of Geology, vol. i. p. 150, ed. 1872.

[3] Etudes Générales, etc., Barrande.

[4] It must always be borne in mind, when arguing from these early fossil molluscan remains, that we have *only the shells* preserved to us. We know nothing of the animals. Our argument then is founded on assumption, and must be treated accordingly. See "Distribution of the Cephalopoda in Silurian Countries," by J. Barrande. Reviewed in Geol. Mag. 1870, Vol. VII. p. 490.

solely on an investigation of the characters of the external shell, a test that is by no means a sure indication of corresponding differences in grades of organization of the animals inhabiting them, and therefore the classification of zoologists is rightly based on those internal characters which affect the life-conditions and habits of the animal,—characters of which we are necessarily often entirely ignorant in the case of fossils derived from the Palæozoic rocks. Again, with regard to the distribution in time, we are confronted with the fact that of the whole 25 Palæozoic genera, no less than 12 varied types, or nearly one-half of the whole, occur simultaneously in all parts of the world at the same geological epoch. This wide distribution of the so-termed primitive types is, however, capable of being interpreted by Evolutionists as proof of their antiquity; and they will probably define the conclusion that they are the first representatives of the group, as an unsound one, based, as it undoubtedly is, on purely negative evidence, and reply that their predecessors have yet to be discovered in some of the unexplored Cambrian areas. But M. Barrande's most valid objection to the theory of the evolution of the class, one with which I am not competent to deal, is assuredly that founded on a critical investigation of the embryonic characters of the *Ammonitidæ* and *Goniatidæ*, as compared with that of the *Nautilidæ*. These researches lead him to the conviction that important embryological distinctions exist between the development of the *Ammonites* and *Goniatites*, and that of the *Nautilidæ*, which preclude the reception of the idea that the Secondary *Ammonitidæ* were derived from the *Goniatites*, and they, in their turn, from the primitive *Nautili*. To quote from the able and most instructive anniversary address of the late President of the Geological Society,[1] Professor Martin Duncan, F.R.S., "The examination of the earliest formed portion of the shell of *Nautilus* and *Goniatites* indicates embryological distinctions, and, therefore, it is necessary to seek in the remoter Palæozoic *Nautilidæ* for the ancestors of *Nautilus* and *Goniatites*."

One further point deserves notice, namely, the occurrence at various geological horizons of distinct generic forms, which represented by a few, or possibly by several species, nevertheless die out at the close of that short geological period, and never re-appear.

> "So careful of the type?" but no,
> From scarped cliff and quarried stone
> She cries, "A thousand types are gone,
> I care for nothing, all shall go."
>
> Tennyson's *In Memoriam.*

This fact, which is observable in many other groups of organisms, notably in that of the *Brachiopoda*, as was so clearly explained by Mr. Davidson[2] in his admirable memoir, is explicable only, either by the hypothesis of descent with modification, or by that of the doctrine of special creation. In this instance it would perhaps

[1] Quarterly Journal Geological Society, London, May 1st, 1878, p. 69.

[2] What is a *Brachiopod?* Brighton and Sussex Natural History Society, Feb. 11th, 1875; Geological Magazine, April, May, June, 1878; Annales de la Société Malacologique de Belgique, 1876.

seem a more exalted conception to infer that, in these abandoned types, we have the modified descendants of a few remotely antecedent created types, than to maintain that, in common with the numberless specific varieties, they were each individually created at successive and constantly recurrent periods,—for the fact that they made their appearance on the earth at very different epochs of geological time, is as indisputably proved as that of the orderly and successive progression from the Crustaceans and Molluscs to the Fishes, Reptiles, and Mammals. But I will not enter further upon the speculative controversies as to the origin of the Cephalopoda. Scientific doubts and perplexities, like all other intellectual difficulties, should be solved by individual thought, the result in most cases being dependent on the peculiar bias of the observer. In this necessarily imperfect sketch of the annals of the Cephalopods, I have merely endeavoured to place the evidence impartially before you. I wish, however, to be understood as clearly distinguishing between what may be termed "Rational Evolution," a phase of the doctrine based on legitimate deductions from well-ascertained facts,. as widely separated alike from "Advanced Darwinism" and dogmatic Materialism. The investigation of the past history of any group of organisms inevitably trenches on the theories of Evolution; for, in the words of one of the most popular exponents of palæontological science, Dr. Alleyne Nicholson,[1] "it is to that science, perhaps more than any other, that we may look for the key to some most interesting and important theoretical problems in biology."

*Note.*—The writer regrets that she has only now had her attentention called to a most interesting paper by Prof. Owen, entitled "Observations upon the Camerated Structure in the Valves of the Water-clam (*Spondylus varius*, Sow.)," which was originally printed in the Proceedings of the Zoological Society for June, 1837, and afterwards in the Magazine of Natural History, vol. ii. 1838, p. 407, in which the author traces out the connexion between the mode of growth in *Nautilus* and that of other molluscs which partition off a portion of their shell not required for the convenience of the soft parts of the animal inhabiting it. Although in this paper Professor Owen speaks of the siphon of *Nautilus* as a means for converting the deserted chambers of the shell into "a hydrostatic instrument subservient to the locomotion of the animal," yet he clearly points out that the septal divisions of the Nautilus-shell are analogous to the septa of the "water spondylus" and many other shells which partition off the dis-used portion of their houses both among univalves and bivalves.

Dr. Henry Woodward, F.R.S., to whom Professor Owen showed this paper a few days since, was, he informs me, until then, wholly unaware of its publication, and only regrets that he did not discover it when writing upon the subject of Camerated Shells, so as to have given Professor Owen due credit for these views published so long before his own.—A. C.

[1] Recent Progress in Palæontology, Geological Magazine, January, 1878; the Inaugural Address to the Edinburgh Geological Society, November, 1877.

## III.—The Physical Forces which have caused the Present Configuration of the Valley of the Calder in Yorkshire.[1]

By James W. Davis, F.L.S., F.G.S.,
Hon. Secretary of the Yorkshire Geological and Polytechnic Society.

BY way of introduction to the subject of this paper, I will very briefly describe the physical features of the country drained by the River Calder. We shall thereby gain a clear idea of the present configuration of the Calder valley and better understand how the forces have operated which have produced the grand diversity of hill and valley, of moorlands bleak and wild, of precipitous crag, and steep, wooded slopes, and of the lower lands, rich and fertile, which extend along their base. To know clearly *what* has been done, is more than half to understand *how* it has been done.

The River Calder is, roughly speaking, about forty miles in length, and drains about 400 square miles of land. It has its source in several small streams which rise far up in hills around Todmorden. The principal feeder has its origin in Lancashire, and passes through a break in the chain of hills separating that county from our own. Pursuing an easterly course, the united streamlets wend their way from Todmorden to Hebden Bridge, and are there joined by a large tributary from the Wadsworth and Widdop moors. It is the stream from the latter that is intercepted and collected into large reservoirs by the corporation of Halifax. The water is conducted thence in a large conduit, which passes at a depth of 500 feet or more, under Wadsworth moor, and so on to Halifax. A short distance below Hebden Bridge is another very pretty village called Cragg, and passing through this is a small river which descends from the moorlands of Langfield. No doubt many of my readers have been either to Hebden Bridge or in Cragg valley, and will have a vivid recollection of those really delightful places. They will remember the precipices of sandstone, which rise from the level of the bed of the stream, in some instances, as at Hebden Bridge; succeeded by gentler slopes, which are either covered with trees or grassland. Originally they were all wooded, the trees having been cut down during late years by the farmers and others, who thought they could make some profit out of the land if they could use it for grazing cattle or growing corn, whilst if the trees remained they would probably not be able to do so. The result of this utilitarianism has been to render many parts of the valley far less pretty than they would have been had the trees been left standing.

The grassland generally extends high up the hills, to the verge of the moorland, which everywhere covers the tops of the hills, stretching away mile after mile, in long monotonous undulations; occasionally a stream cuts deep into the surface, otherwise there is little to break the sameness which exists on all sides. The moors are covered with furze and heather, with occasional small patches of short green grass. They are wholly given up to grouse and a few sheep. The

[1] Read at the Orphanage, Halifax.

decay of the heather produces peat, and this in most places has a thickness of from six or eight to twelve feet; below that again is sandstone. 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.

Leaving these elevated moorlands for a time, let us follow the course of the river from Mytholm to Sowerby Bridge. It passes amongst steep declivities of shale or more precipitous "edges" of gritstone; generally the shale slopes up to the foot of the grit, the latter projecting in angular cornices above it. This is the character of the scenery, not only of Calder valley, but also of the tributaries which join it from the Ripponden and Luddenden valleys, and those from Halifax on the one side, and Barkisland and Stainland on the other. Below Elland, the valley, which has been hitherto very narrow, assumes greater proportions, its surface being arranged in a series of long level flats through which the river has cut its channel with many devious turnings and windings. The valley is bounded on either side by hills, which rise to a considerable height, but are characterized by a more rounded outline than those nearer the source of the river. The escarpments of sandstone are wanting, and though the general character of the two areas is somewhat similar, there is still sufficient difference to indicate to an experienced eye that they are not of the same geological composition. Such is, in fact, the case; the river in its initial stages runs amongst hills of Millstone-grit, whilst from Elland, downwards, its course is amongst the Coal-measures. The former are characterized by thick beds of sandstone, which form the steep escarpments already described; whilst the latter, composed more largely of shale with beds of coal, form rounded summits only, now and then capped by a bed of flagstone.

The country becomes flatter until Wakefield is arrived at, after which the hills gradually disappear; and, with many convolutions, often turning quite round, and running a short distance backwards, the river reaches Castleford and empties itself into the Aire. The district about Lofthouse, Methley and Normanton is comparatively flat and tame. It is composed of the Middle Coal-measures, and forms a rich agricultural district. Its greatest value is, however, not on the surface, but in the mineral wealth, which lies buried hundreds of feet below. The Coal-pits, which are numerous, do not tend to improve the appearance of the country.

The geological structure of the country drained by the Calder next demands consideration. The whole of the rocks in this area constitute a part of what is called the Carboniferous system, so named from the occurrence of great quantities of coal found in "beds," especially amongst the upper members of the series. The strata which form the surface are comprised in descending order in the *vertical section* following:—Middle Coal Measures, Lower Coal Measures, Millstone Grits, Yoredale Rocks. The Yoredale rocks occupy the bottom, and some distance up the sides, of the valley at Todmorden. They consist principally of shales, with beds of sandstone, and only differ from the Millstone rocks above them in this: that the *Yoredale rocks* are mainly *shales* with a comparatively small quantity of sandstone interbedded, whilst in the *Millstone-grits,* the sandstone beds of which are used for millstones in grinding corn, the characteristic features of their composition are the thick beds of sandstone which occur abundantly throughout the series, and may be seen capping all the hills in this neighbourhood. Just in the same way, the lower and upper members of the great Carboniferous system are characterized; the former by the immense quantities of thick-bedded limestone composing it, and the latter by the frequent occurrence of beds of coal. The one called the Carboniferous Limestone, the other the Coal-measures.

By far the greater portion of the 400 square miles drained by the River Calder and its tributaries is composed of Millstone-grits and Lower Coal-Measures. The Millstone-grits extend from the boundary of the county eastward to a line extended roughly from Halifax a little west of Huddersfield, which would separate them from the Lower Coal-measures.

The Millstone-grit rocks, with the superincumbent Coal-measures, form parts of an immense anticlinal ridge, whose apex extends along the summit of the chain of hills dividing Lancashire from Yorkshire. On the side of Lancashire the dip or slope of the rocks is very rapid, whilst that on the Yorkshire side of this chain of hills is comparatively gentle. The woodcut on page 504, to which I shall again refer, will explain this relationship. Originally, the Coal-fields of the two counties were united, and formed one large, and, we may suppose, level plain, over which the sea occasionally encroached for long periods. During the Millstone-grit age the sea had the best of it, and during the deposition of the great thicknesses of shale which lay between the grit rocks, the land was under water. The gritstones themselves formed the sea-bed, but were near the shore, and probably washed and ground by every advancing and receding tide—the grains of sand composing the sandstones, when examined with the assistance of a magnifying lens, will be found to be more or less spherical; the hard, sharp, corners having been removed by the constant rubbing of one particle against another whilst they formed the sands on the shore of this old land. A specimen from the quarry on the edge of the moor will abundantly prove what I have said, and if a piece of stone be chosen with large quartz pebbles inclosed, such as very frequently occur, the rounded and waterworn form will be easily identified. Both the sandstones and the shale are the result of the disintegration of a still older land, just as the Permian Limestone, which stretches in a line N. and S. across the county, a little beyond the confluence of the Calder with the Aire, has been derived from the Mountain Limestone of the Fell district to the north of the Calder valley. The Millstone-grits were probably deposited near the shore, being brought down by rivers from the land adjoining, whilst the finer and more impalpable mud would be carried further out to sea, before it settled to the bottom. This mud has formed the great bed of shale. One feature is particularly noticeable in connexion with the deposits from this old sea, and it is a feature that is usually remarked at a very early period in the researches of young geologists: it is this, that there are an extremely small number of fossils found in the beds of shale or rock. The sandstone may be hammered by the youthful enthusiast, where exposed in a natural escarpment, or in the numerous quarries which occur very abundantly near Halifax, with no better result than the acquisition of a fragment of a tree stem or a fossilized impression of a fruit-cone of a tree to which the stem belonged; whilst the shales, except in a few rare instances, appear to be absolutely devoid of organic remains. This absence of fossil animal remains may probably be accounted for by the intermixture with the shales of a large per-centage of iron, which was deposited at the same time as the mud, and consequently was held in suspension by the water. Most of my readers know, that where the water is tainted with iron, or, as it is frequently termed, is "cankerey," no fish or shells can exist; at any rate, this is the case if the iron is present in considerable quantities. During the Millstone-grit age, or the time at which these rocks were deposited, the waters appear to have been very "cankerey" indeed; and, as a natural consequence, fishes and molluscs were either very rare, or they were altogether absent;—only the broken fragments of the stems of trees, brought down by the rivers from the adjoining land, being found, as already said, in these strata. Though, however, these may be considered the general palæontological characteristics of the strata, on the west and north of Halifax there are two or three exceptions, which may be worth pointing out. On Wadsworth moor, about a mile and a half from Hebden Bridge Station, a shaft was sunk in making a passage through the hill, for the water collected on the moorlands above Widdop to be carried to Halifax. This part is composed of the Third Grits, and at about 300 feet from the surface a bed of limestone occurred, which contained fish-remains, and numerous fossil shells. If any collector would like to gather some of these fossils, they may yet be found on the heap of shale and stones at the mouth of the pit, and will repay a visit. The other sections where fossils may be got, other than plants, are at Wheatley and Ogden, beneath the Rough Rock, but these can only be found by experienced eyes.

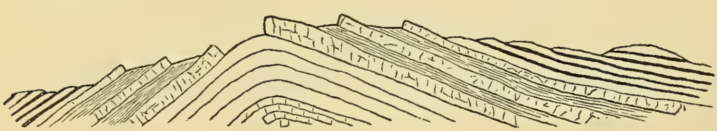
Turning next to the *Coal-measures*, we find that great changes have taken place. There were still long periods during which the land was *under water*, and thick beds of shales and sandstone were the result, but the principal feature of this age consisted in the formation of thick and numerous beds of Coal. I will not enter into the question of the formation of Coal, for it is one which has engaged much attention, and about which there are several plausible theories, merely premising, that the coal is the result of the accumulation of large quantities of decayed vegetable matter, which, by pressure and some chemical changes, has been turned to the black carbonaceous substance with which we are all so familiar. Besides these rich deposits of vegetable origin, with their beautifully preserved specimens of ferns and other land-plants, there occurs a great number of the fossil remains of shells and fishes which lived in the water, and also of a few insects and labyrinthodonts which existed mainly on the land. Specimens of these fossils may be found on almost any pit heap, and are especially abundant in the Halifax Coal-strata and above the Better Bed Coal of the Lowmoor district.

After this digression, we must hasten to consider some of the physical forces which are, or ought to be, the subject of this paper. Perhaps the most important is the great internal force which caused the elevation of the chain of hills dividing this county from Lancashire, called the Pennine Chain of Hills or the Backbone of England. This upheaval is part of an extensive system of faults which extended primarily in two directions, viz. one running north and south—the Pennine system of faults—extends from the eastern side of the Lake-district southwards to Staffordshire, passing, on its way, along the western boundary of Yorkshire. The second great line of faults is in an easterly and westerly direction. They are called the Craven Faults. They branch from the Pennine Faults near Ingleton, and, proceeding eastwards along the foot of Ingleboro', pass behind Settle to Malham, and thence still further into Wharfedale. The displacement of the rocks by these faults is very great. In Lunedale the New Red Sandstone abuts against Silurian rocks, and the beds must be displaced to the extent of nearly 3000 feet. At Ingleton, the Coal-measures are placed by the Craven Fault on a level with Silurian rocks; further east, at Malham, the Mountain Limestone on the north is in a line with the Millstone-grits on the south side of the fault.

In the district we are considering the break seen in the rocks is not so distinct, but they are forced up into an anticlinal as represented in the subjoined diagram.

Diagrammatic Section across the Pennine Anticlinal.

Lancashire. Yorkshire.



4 3 2 1 2 3 4

1. Mountain Limestone.
2. Yoredale Rocks.
3. Millstone Grit.
4. Coal Measure.

To understand this action it will be necessary to premise that the earth's crust is constantly changing its form, even at the present time, and that, formerly, the changes appear to have taken place much more rapidly. The strata or rocks of which the outer surface of the earth is composed are not everywhere of the same thickness and strength, and, consequently, are not able to bear uniformly a lateral pressure, such as would be produced by the cooling, and consequent contraction, of the whole mass. Where the earth's crust is thinner than in other places, or, from some other cause, happens to be weaker, it is most likely to give way, and this seems to have been the case in the district which now forms the range of hills westwards from Halifax. 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.

Suppose there are 10,000 feet of strata, for the action extends much lower than the rocks which are visible, lying horizontally one above another; then imagine a force pressing this mass from below with sufficient strength to bend or bulge it outwards, what will be the consequence? The stratum, which we will suppose to be a sandstone, occupying the surface, will be bent upwards, until it can no longer bear the strain, when it will burst or break into two parts, leaving a space between. The upheaval may have been, in all probability was, a very slow process. It is not at all necessary to suppose that the movement was a rapid one, or that it took the form of a gigantic earthquake or other cataclysm of that nature. The pressure may have been gently but persistently applied, and the operation have extended over ages. 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. This is the kind of action which actually occurred during the elevation of the Pennine Chain. If any one, walking from Halifax to Blackstone Edge, took the trouble to notice, he would find that he passed over the several outcrops of the Rough Rock and Flagstone, which presents an escarpment to the westwards, where its existence terminates; then the series of Third Grits, which are greater in number, but not so thick and important as the rocks above and below; and finally the great precipitous cliffs of the Lowest or Kinder Scout Grits would be found terminating abruptly on the summit of Blackstone Edge, forming the boundary of the county.

Between each of the escarpments of sandstone, a much more even tract would be passed over, which on examination would be found to be shale.

We have now glanced, very briefly, over the *physical contour*, the *geological structure*, and the *internal displacement of the rocks*, forming the surface, and we know now what kind of material the physical forces, some extinct, others in daily operation, have to work upon.

It has already been observed that the bed of the river, from Sowerby Bridge eastwards, runs through a series of somewhat level plains, not unlike the appearance that would be presented by a string of lakes joined together by a broad river. Where the structure of these level tracts has been exposed, by sinking wells or other means, it has been found to consist of sand containing a great number of rounded stones. Such a section was exposed in digging for the foundation of the railway arch which crosses the river at North Dean. The upper part of the section was found to consist of sand and stones or boulders which had evidently been derived from the sandstones of the surrounding country. The lower part, however, about twelve feet in depth, contained, besides stones of local origin, others which had been conveyed from very long distances.

In many places along the sides of the valley, at Hebden Bridge, Mytholm, Elland, and at Kirklees Park, there are deposited beds of water-worn stones and sand. Take the section at the Elland Cemetery for example. There is a considerable thickness of sand, containing immense numbers of rounded stones and occasional bits of shale. It rests on shale belonging to the Lower Coal-measures, and reaches from the Cemetery down the hill-side towards the river, and is cut through and well exposed by the railway at Elland Station. This bed is altogether different from the one in the bottom of the valley at North Dean, and they do not present the appearance of having been at any time connected with each other.

This deposit is just such a one as would be left by the tapping or draining of a lake, and it appears a reasonable inference that at one time the valley of the Calder was dammed up to the height of these deposits, and that by some means the barrier or embankment at its south-eastern extremity was removed and the water subsided, leaving evidences of its existence, which may formerly have been much more extensive than at present, in the terraces of rounded stones and sand formerly constituting its shore, and which we now find at considerable elevations above the present level of the valley. Whether these terraces are older than the boulder beds in the bottom of the valley, must remain an open question. I do not think there is sufficient evidence to solve it at present.

The peculiar feature about the deposits exposed at North Dean, and many other places lower down the valley, is the occurrence, in the lower part, of blocks of granite and syenite amongst stones derived from the Millstone-grits which bound the valley. How came they there? The nearest points where they are found *in situ* is either Cumberland or Wales, and consequently they must have travelled or been carried to their present locality from either one or the other of these localities. It appears most probable that they came from Cumberland, for we know that a great glacier descended along the western slope of the Pennine Chain from the Lake-district and Scotland, and also that a considerable branch passed over Stainmoor into Wensleydale, and found its way into the great flat country of central Yorkshire, of which the city of York is the centre. You may ask how this is known, and what proofs there are? In reply, there is a mountain on the borders of the Lake-district called Shapfell, which is composed of a peculiar kind of granite containing very large crystals of felspar. This peculiar granite is not found elsewhere, and its occurrence in other localities, in detached and rounded fragments, proves that it has been conveyed by some means from

Shapfell to the position in which it is found. The evidence that it has been conveyed by ice is also very conclusive. Where the boulders of Shap granite, or those from other localities, are found imbedded in clay, they are covered with fine scratches. Now the only agent with which we are acquainted which can scratch the stones in this peculiar manner is the grinding and rubbing action of a mass of moving ice, such as constitutes glaciers. The boulders in Lancashire and the more eastern parts of Yorkshire are scratched in the way indicated; but those in the Calder valley are not scratched or striated, and there is no evidence that a glacier ever occupied this valley. The way these erratics appear to have got into the valley is as follows. They were brought by glaciers into the valley of the Ouse along with glacial clay, and deposited there. After a while the level of the land was lowered, and the glacial deposits were subjected to the action of the waves. The boulders were washed out of the clay, and rolled about the bottom of the sea, until the scratches were obliterated and the corners worn off.

At this time the valley of the Calder was submerged. Its channel, subject to the fury of the waves, would soon become much deepened and wider. The shales beneath the Grit-rock, from their loose and incoherent structure, would prove an easy prey to the waves, and be readily washed out. The Grit-rocks above them are broken into huge cubes by fractures extending vertically in all directions, and, as soon as their support was gone, these cubes of rock would fall down, and, subjected to the action of the waves in their turn, would be broken into smaller pieces, the corners and sharp edges removed, and they would form the boulders we find at the present time filling up the valley. Intermixed with them, the boulders of foreign origin, washed up by currents from the not far distant valley of the Ouse, would be deposited at the same time. After a while, on the re-emergence of the land, the flat plains, formed as described, would exist in very nearly the form we see them at the present day.

I have reached the concluding portion of my subject, and have only a little more to say respecting the sub-aerial denudation that is always in progress, at a greater or less rate.

The principal agents are rain and streams, springs and frost. Their effects in forming the contour of the surface may be seen everywhere. Valleys are seen cut deep into the solid rock, and still deeper into the shales below. Landslips frequently occur, caused by the underlying strata being washed out by springs; or the rocks, having been saturated with water and subjected to the action of frost, are, by the expansion of the water during freezing, forced off in masses which lie strewn on the hill-sides. I have already remarked on the liability to erosion by the sea of the beds of rock in the valley of the Calder. We find, universally, that a bed of grit overlies a bed of shale. You will find such to be the case in the sections exposed in Copley valley.

The sandstone acts as a huge reservoir for collecting and holding water. In wet, rainy seasons, such as we have experienced during the past summer, the sandstones are like great sponges; all the interstices between the grains of sand full of water. The water gradually settles or filters to the lower part of the sandstone, and, reaching the base, it meets with the shales, and its progress is stopped in that direction—perhaps not entirely, but nearly so. If the sandstone occupies a hollow, it fills up until the lowest part of the shaly rim be reached, when the water bubbles out as a spring. If, as is usually the case in our district, the beds are inclined at a tolerably persistent angle, the water drains to the lowest part, and is there "thrown out" at the junction of the shales with the sandstone. A good example of the former kind of spring occurs on Norland Moor, at what are called the boiling wells, so named from the appearance of boiling presented by the water as it bubbles up; and for examples where the water is thrown out by an impervious bed of shale, you will find many along the base of the escarpment in North Dean wood. I do not think you would be very likely to find any on this side of the valley, because the rock dips or slopes towards Halifax, and the water would of course follow the same direction. This throwing out of water proves an important element in increasing the width of the valley, for in its passage, minute quantities of the shale are carried away, and the action continuing for long periods, the foundation of the grits above is loosened or removed, and the masses of angular-jointed sandstone fall from their position and lie strewn over the slope below. From the peculiar manner in which the grit rocks are jointed, they generally break away in rectangular blocks, leaving a still perpendicular surface to be further acted upon. Very fine examples where a whole hill-side has been precipitated into the valley below, may be seen at "Buckstones" beyond Barkisland, and also between the latter place and Ripponden.

The amount of débris carried away seawards by the River Calder is something enormous. If you were to take a glass of water from the river during a flood, or freshet, when the water is muddiest, and let it stand until the matter it contained had settled to the bottom, it would at once be seen that it forms really a large per-centage of the weight of the whole. Next calculate the millions of gallons of water that pass away in a day or a year, and you will be astonished to find how many tons, thousands of tons, of our *everlasting hills* are removed to another place, very likely some quiet corner at the bottom of the German Ocean, which in ages to come will be filled up and form dry land again. And so the cycle of changes in the structure of the surface of the earth constantly proceeds; nothing is fixed, nothing firm; sandstones, shales and limestones are accumulated beneath the waves, are raised up and form dry land, are subject to internal displacement, forced up into high mountains by volcanic action, only to be again ground to powder by frost, rain, and wind, and carried away by the rivers to form new strata in the sea-bottom. This has been going on from the beginning, and will proceed to the end.

## IV.—On the Occurrence of Marine Shells in the Boulder-clay at Bridlington and elsewhere on the Yorkshire Coast.

By J. Lamplugh,
of Bridlington Quay.
With Notes by F. A. Bedwell, Esq., M.A., F.G.S.

In 1874, whilst searching in the Boulder-clays south of Bridlington, on the Yorkshire Coast, for transported fossils, I was greatly surprised to find a few water-worn fragments of shells dispersed through the clay at the base of the cliff, inasmuch as all the writers on this subject agree in assigning to the Yorkshire Clays "no contemporaneous shells whatever,"[1] that is to say, no shells actually coeval with the deposition of the clay.

From that time I carefully searched for, and preserved all these fragments, obtaining, however, only a very limited number of species; until a short time ago, when I had the good fortune to witness a small exposure on the south shore, close to the town, of a bed of clay, which is usually covered deeply with sand and shingle, so exposed, and is very different from the Purple clay of the adjoining cliff. In this clay, shell-fragments were more plentiful, and perfect, and I obtained from it the remains of about a dozen species; and by recent and more extensive exposures, have been enabled to raise this number to about thirty species.

As these shelly clays are evidently very closely connected with the "so-called Bridlington Crag,"[2] a deposit which is only partially understood, I doubt not that a detailed account of them will be found to possess interest.

The two distinct masses into which the Boulder-clay in this neighbourhood is divided, are marked, not only by their lithological characters, into 'Blue' and 'Purple,' but also by the presence between them of a thin bed of laminated 'snuff-brown' clay, which for the most part contains no pebbles whatever, being very pure and soft, and remarkably tenacious.

This snuff-coloured clay seems to be a strictly local deposit, occurring only in Bridlington Bay. It appears both to the north and south of the town. To the north it may be traced at intervals along the base of the wasting cliff, for a few hundred yards northward from beneath the lime-kiln. To the south it is at present well exposed on the South Sands[3] between high and low-water marks, for about three-quarters of a mile, and it then either thins out or sinks beneath the sea, a point which can only be ascertained by careful examination of well-borings, etc., further south; but I am inclined to think that it will not be found to extend further than the place above indicated, viz. halfway between Auburn and Bridlington.

Its thickness, which is evidently very variable, is 40 inches at the

[1] Phillips' Geology of Yorkshire, 3rd ed. p. 164; Wood and Rome, Quart. Journ. Geol. Soc. vol. xxiv. p. 147.

[2] For some account of the Bridlington Crag see a paper by Dr. S. P. Woodward, F.G.S., Geol. Mag. 1864, Vol. I. p. 49.

[3] The beach to the north of Bridlington is locally known as the "North Sands, and that to the south of the town as the "South Sands."

point where it sinks into the beach to the south of the town. From its position on the shore I judge that it occupies extensive hollows in the 'Basement' Clay. Towards its junction with that mass small pebbles make their appearance, otherwise it is remarkably free from any foreign admixture.

The beds which immediately underlie this laminated clay, on both the North and South Shore, are those to which I would more particularly draw attention on account of their near relationship to the mass of sand and shells known as the Bridlington Crag, which evidently forms part of this division.

Lithologically, they consist of a dark sandy, sometimes earthy clay, of a dark greenish-blue colour when damp, but having a more decidedly green tinge when dried. The pebbles contained in it are chiefly small, and consist of fragments of rocks from strata exposed along the coast to the northward, being derived principally from the Lias, Oolite and Chalk, with an occasional fragment from the Septarian nodules of the Speeton Clay, and with others from rocks at far greater distances. On the whole, it is not nearly so pebbly as the 'Purple' Clay, for although in some patches pebbles are very plentiful, in others they are nearly absent. In one or two places there appear in it what have evidently been at some time masses of chalk; but these are now so crushed and disintegrated as to resemble streaks of rough pipe-clay.

These sandy clays form the top of beds which I identify as the 'Chalky' or 'Basement' Clay of Messrs. Wood and Rome. On referring to their paper,[1] the reader will find that these gentlemen only extend this division as far north as Skipsea, doubtless never having witnessed the exposure of the beds on the South Beach which lie just above the extreme low-water mark of spring tides, consisting of the same 'leaden-coloured' clay, and characterized by nearly the same abundance of chalk as the 'Basement' clay described by them as occurring further south.

It is in the above-mentioned sandy clays on the South Shore that I have found the shells in question in the greatest abundance, though I have also actually obtained them from the 'Basement' clay itself.

Bearing in mind the marked distinction observable between the 'Basement' clay and the 'Purple' clay, exhibiting, as I think, a distinct alteration of some kind in the nature, and possibly in the direction of the glacial action, I was very much surprised to find that actually in the Purple clay itself, and at heights varying up to twenty feet above the horizon of the sandy bed already described, there were to be seen fragments of the very same shells mixed up with its mass, and included in the débris gathered in by the glacial action which deposited this clay. It was these fragments of shells which I first discovered in 1874, and which attracted my attention to the subject at a time when the 'Bridlington Crag' deposit was wholly invisible.

Having identified the fragments in the 'Purple' clay with the shells found in the 'Basement' beds, I was led to follow up the

[1] Quart. Journ. Geol. Soc. vol. xxiv. p. 170.

subject more extensively; and to my further surprise found fragments of the same shells everywhere on the coast as far north as Whitby,[1] beyond which place I have not yet sought for them. And it is remarkable, that wherever a double series of clays, as noticed by Prof. Phillips,[2] can be observed, as is the case at Filey, Cayton, Whitby and elsewhere, it is in the lower bed that the fragments are always most plentiful and least water-worn, and this lower bed is always the darker in colour, generally of a greenish tinge, and very distinct from the upper bed, which is usually of a reddish brown colour, north of Flamborough. This is especially noticeable in the cliffs near Filey, and to the north of the last-named locality there exist, between the two clays, traces of a bed of laminated sand and clay corresponding, as I believe, to the 'snuff-brown'-coloured clay at Bridlington. I was only able to trace this bed for a short distance; its thickness was about two feet.

From these facts, I think that a representative of Messrs. Wood and Rome's 'Basement' Clay will be found to exist to the north, as well as to the south of Flamborough, but on this head further investigation is required.

The vast majority of the shells found in the sandy clays on the South Sands at Bridlington are fragmentary. Some of these fragments, even when found in the sandy clay, are quite water-worn and rounded, but more have their angles as sharp as though newly fractured, which is rarely the case with those present in the 'Purple' clay. They are also more abundant in some patches than in others, being generally most plentiful just below the laminated clay already described. I have given below a tabular list of the species already found by me both in these beds and in the 'Purple' clay, and the specimens have been submitted by me to Dr. Henry Woodward for more critical examination.

That these shells are derived from the same source as those in the 'Bridlington Crag' is, I think, unquestionable; from which it follows that this 'Crag' sand, with its numerous shells, lies in the 'Basement' or 'lead-coloured' clay, and not in the upper 'Purple' clay, as is suggested by Messrs. Wood and Rome.[3]

There is a very strong argument in favour of this, by the undoubted presence in the 'Basement' clay at Dimlington, further south, of a similar shell-bed, which contains the same species, and is, I believe, generally regarded as forming part of the same series as the 'Bridlington Crag.'

The position of the 'Crag' furnishes us with another proof, for I have myself witnessed an exposure of the upper part of the 'Basement' beds on the North Beach beneath Fort Hall, close to the place where the 'Crag' was first discovered. The same 'Basement' clay is again exposed on the beach about 800 yards further north, consisting of the same dark sandy clay with many shell-fragments, and overlaid, as on the South Sands, by the snuff-coloured clay.

[1] At which place however they had become very rare.
[2] Quart. Journ. Geol. Soc. vol. xxiv. p. 254.
[3] Quart. Journ. Geol. Soc. vol. xxiv. p. 149.

Again, patches of sand and gravel interstratified with and surrounded by the 'Purple' clay, are to be found in many places in the cliffs both to the north and south of the town, and these contain no shells whatever; whereas, as already mentioned, those included in the 'Basement' clay contain them in abundance, and this I refer to as another argument in the same direction.

In the tubes of the *Dentalia*, and under a perfect valve of an *Astarte*, obtained from the sandy clays on the South Shore, was a true coarse 'Crag' sand, showing the character of the bottom on which these shells lived. Parts of the sandy clays (already mentioned as forming the upper portion of the 'Basement' clay), when dried, greatly resemble the true 'Crag' both in colour and composition, having the same greenish cast and containing the same small black cherty pebbles.

From these facts, and others, furnished by the direction of the beds where they disappear beneath the town, I think it is evident that the 'Bridlington Crag' forms a part of the 'Basement' and not of the 'Purple' Boulder-clay series.

The 'Purple' clay, which forms by far the greater part of the whole deposit along the coast, has been so often and so well described, that it is almost needless to enter into special details respecting it. It is of a dark purple to the south, and of a reddish-brown to the north of Flamborough, and contains more and larger rock-fragments than the 'Basement' clay; and a large proportion of these fragments have been derived from a distance, masses from the Coal-measures being very abundant. The majority of the fragments have their angles only slightly rounded, but are often scored and scratched in all directions.

In many places in this locality, patches of sand and gravel of considerable area (even from 80 to 90 yards in longitudinal section) occur in this clay; and it is a noteworthy fact that, as has already been observed, no shells are present in these patches, a strong proof that the fragments of shells which I find in the surrounding clay have been drifted or carried with the other ingredients of the clay, for had they been living in the neighbouring waters during the time the 'Purple' clay was in process of formation, we might have reasonably expected to find their perfect remains in these inclosed sands, precisely as they are found in the sand-beds in and on the 'Basement' clay.

The thickness of the 'Purple' clay in this neighbourhood is very irregular, and its upper surface is deeply eroded into innumerable hollows, which are often partially filled with a rough heterogeneous gravel, evidently in great part derived from the clay itself, and I agree with Messrs. Wood and Rome in concluding that the mass has suffered extensive denudation.

Sparsely scattered through this clay from top to bottom are the shelly fragments already referred to as being those which first attracted my attention to the subject. They are more water-worn and rounded than those from the lower beds, and rarely, or never, approach perfection, the hinge-line and umbo (the strongest part) being generally all that remains. As in the 'Basement' clay, these broken shells are more plentiful in some places than in others, and where these patches occur, the shell-fragments are scattered (*not stratified*) throughout a limited area, whilst the surrounding clay is almost destitute of specimens; but nowhere are they nearly so plentiful in this division as in the lower.

In the South Cliff this 'Purple' clay often shows indistinct lines, suggesting stratification, and, indeed, in many places deserving that name.

Above the gravel already mentioned as often covering the 'Purple' clay, lie variable and inconstant (as, indeed, nearly all the beds above the clay are) beds of laminated sand and warp, sometimes of considerable thickness.

The surfaces of the laminæ of both sand and warp are often, as noticed by Professor Phillips,[1] curiously waved, as though broadly ripple-marked, and in one place I found the plates of warp pitted, as though by rain. At one or two points in the South Cliff the sands are curiously contorted and cross-bedded.

Overlying these beds is generally a mass of gravel, chiefly of chalk, of a thickness varying in the South Cliff from half a foot to four feet, but to the North of the town it is much thicker; and this, except where the fresh-water marls intervene, is directly covered by the surface soil.

Before proceeding to consider the conditions under which these varying deposits were accumulated, it will perhaps aid the reader's perception if I lay before him a summary of the results I have now arrived at as to the division of the Drift in this locality, placed side by side with the typical one set forth by Messrs. Wood and Rome in the paper already alluded to. (See table on p. 514.)

The origin of the beds lying above the 'Purple' clay in this locality is not difficult of explanation, being evidently due to intermittent periods of stormy and quiet seas, of strong ocean currents and placid lake-waters.

But when we come to consider the conditions under which the Boulder-clays, with their associated Sand-beds, were formed, especially with reference to the presence of shells in their midst, we meet with many difficulties.

On the one hand, the broken condition of the vast majority of the shells, the worn character of many of the fragments, and the way in which they are dispersed through the clay, would lead us to suppose that they had been carried hither with the rest of the materials of which the clay is formed (as, indeed, evidently has been the case with those in the 'Purple' clay).

On the other hand, the presence close by of a considerable body of sand and shells (some with valves still united), the entirely unworn character of some of the fragments, and the fact of sand still remaining in the hollow of a single valve of *Astarte*, forbids the supposition that such shells could have been drifted from any distance, unless indeed we can imagine them to have been trans-

[1] Geology of Yorkshire, third edition, p. 82.

| Divisions adopted by Messrs. Wood and Rome, Quart. Journ. Geol. Soc. vol. xxiv. p. 147 *(omitting the freshwater marls).* | Diagrammatic section of the Drift at Bridlington, proposed by J. Lamplugh. |
|---|---|
| Gravel, principally of Chalk. | Chalky Gravel. |
| Sands and Gravels. | Sand, Warp, and Gravel. |
| Hessle Boulder Clay. | Hessle Series absent from the immediate neighbourhood, unless represented by the lower |
| Hessle Sand and Gravel. | Gravel. |
| Purple Boulder Clay, with Sands and Gravels, inclusive of the Bridlington Crag. | Purple Boulder Clay, with Sands and Gravels. |
| Sands, with Gravel. | Locally a bed of laminated Clay. |
| Chalky or Basement Clay. | Bridlington Crag Deposit, consisting of Sands and Sandy Clays<br>lying on and mingled with the Basement Clay. |
| Chalk. | Chalk. |

ported in an immense frozen mass, which is rendered highly improbable by the fact that most of the shells are of deep-water species, and also by the position of the shells, with closed valves, and even, as was witnessed by Mr. Bedwell (see subsequent note), in their natural position as when alive.

The only probable solution of this problem which has presented itself to me, is to suppose that during the earlier periods of the Glacial epoch, a sandy sea-bottom was formed, probably founded on the already partially accumulated 'Basement' clay, on which the shells in question lived and died; and that this bottom, during a period of extreme cold, was ploughed up and destroyed by floating-ice (coming mainly from the north), which, melting, incorporated the sand and broken shells with its own burden, consisting in part of masses gathered on its southward journey. This disturbing process would doubtless be often repeated, thus giving rise to the sandy clays, which have already been described as being the stronghold of the shell-fragments, and as forming part of the 'Basement' clay.

Under this view, the Bridlington and Dimlington 'Crag' beds must be considered as portions of this old sea-bottom which have escaped destruction, and I am inclined to think that the Bridlington Crag beds include conditions, which render it probable that its great thickness and amassed appearance may have been due to the accumulating power of a huge mass of ice, which, grounding (and not, as with the smaller bergs, merely grating) on a soft bottom, would slowly continue its forward course for some distance, forced irresistibly onward by its immense momentum and the pressure of the ice behind, and might push before it a constantly increasing mass of sand and shells which might attain considerable proportions ere the whole came finally to rest. A mass thus gathered would have its greatest thickness in the centre, and would thin out on either hand, and this agrees with the early descriptions of the 'Bridlington Crag' as seen under Fort Hall. This view would also account for the numerous single and broken shells in the 'Crag,' as well as for those in which the valves still remain united, as the latter molluscs might remain alive during the whole forward movement, afterwards resuming their natural attitude and becoming imbedded in that position. I would also suggest this as a partial explanation of the admixture of species from different life-zones, as noticed by Dr. J. G. Jeffreys.[1]

Whilst slowly melting, the ice would form an impassable barrier to the advance of the masses which followed, thus protecting the sand and shells at its landward edge from undergoing the crushing process, an office which might be performed by its transported burden after the melting of the parent mass. And, indeed, some such explanation is needed to account for the presence of these patches of almost incoherent sand, of which the main body has evidently been swept away.

Then must have followed a period of, at any rate local, quiescence, during which the snuff-coloured laminated clay was deposited, the product of still muddy waters, probably of a considerable depth. These conditions may have been owing to some obstacle preventing the access of ice to the neighbourhood.

This was evidently again followed by a return of the ice, this time probably the true glacial stream from the north-west, bearing with it huge masses from the granitic mountains of Cumberland, and from the Carboniferous strata of the West Riding, with the remains of a few land animals[2] (chiefly, perhaps solely, of the Mammoth).

As has already been observed, the 'Purple' seems to be the only clay present on the higher grounds of the coast, the 'Basement' beds not occurring very far above the sea-level, and it is therefore probable that during the formation of the 'Purple' clay, the lower beds were swept away from elevated positions and carried forward, to be re-deposited as a part of the mass then forming. It is to this cause that I would refer the occasional presence of waterworn

[1] Phillips's Geology of Yorkshire, 3rd ed. p. 277.

[2] I have in my possession part of a Mammoth's tusk from this division of the clay.

fragments of marine shells in the 'Purple' clay (which, as I think, evidently came from the landward), viz. to their having been derived from the lower beds; the fact already dwelt upon of the absence of shells from the sands included in the 'Purple' clay being strong presumptive evidence that they were not truly contemporaneous.

It is evident that the materials forming the Purple clay have been dropped through waters of some depth on to the surface of the laminated clay, as the nature of the latter deposit would otherwise have caused it to be readily swept away. As it is, I witnessed one exposure of it on the South Beach which showed remarkable contortions, and to the north of the town, at the point already referred to, beneath Sand Cottage, it is altogether absent for a short space, the 'Purple' there resting directly upon the 'Basement' clay. Probably the glacier, after crossing the chalk hills which form the boundary of Holderness to the north and west, would reach deeper waters, and there, slowly melting, drop its burden quietly through the waters of the sea.

In conclusion, I need scarcely add that, though in the present state of our knowledge of the subject this seems to me to be the best way of accounting for the presence of shells in the Yorkshire Boulder-clays, still I anticipate that further examinations will make it necessary for me to modify these views; for much earnest work and much patient study has yet to be done before the origin of these clays is really settled; and if, in the mean time, I have added but a little to the slowly accumulating mass of information on the subject, I shall feel richly rewarded.

List of Shells from the Upper Part of the 'Basement' Clay (forming part of 'Bridlington Crag' Deposit) at Bridlington, as exposed in the South Sands. Examined and partly determined by Dr. H. Woodward, F.R.S.

Those which occur also in the 'Purple' clay are marked with an asterisk. Those marked with a dagger are additional species obtained by me from the lower clay at Filey and Cayton. Should this bed prove to be merely a sub-division of the 'Purple' clay (the opinion held by Messrs. Wood and Rome), the shells thus marked will, of course, go to increase the list of those already obtained from the 'Purple' clay. (The prefixed c, denotes the shells which are common.)

*Pecten opercularis*, Linn.
*Nucula Cobboldiæ*, Leathes.
**Leda rostrata*, Flem.
*Pectunculus glycimeris*, Linn.
*Cardium edule*, Linn.
„ *Parkinsoni*, Sby.?
„ *Grœnlandicum*, Chemn.?
c **Cyprina Islandica*, Linn.
**Astarte elliptica*, Brown.
„ *compressa*, Montagu.
c * „ *borealis*, Chemn.
† „ Sp.
*Venus* (?)

c **Tellina solidula*, Pulteney.
c * „ *obliqua*, Sby.
*Mya truncata*? Linn.
† „ *arenaria*? Linn.
†*Lutraria elliptica*, Lam.
*Saxicava rugosa*, Linn.
*Pholas crispata*, Linn.
**Dentalium entale*, Linn.
*Trochus ziziphinus*, Linn.?
*Buccinum undatum*, Linn.
†*Balanus crenatus*, Brug.
„ *tintinnabulum*, Linn.

NOTE.—It will be seen that, with one or two exceptions, the commoner shells alone are met with in the 'Purple' clay, as might be expected from the theory here advanced as to their origin.

The rarity of the remains of univalves in these clays is, doubtless, owing to the character of their shells, which are more liable to be crushed than are the bivalves, consequently, half a dozen fragmentary *Columellæ*, and the body-whorl of a *Buccinum*, are the only traces of Gasteropods that I have found. [Two fragments of derivative fossil shells may be mentioned, one of *Productus* from the Carboniferous Limestone, the other of *Inoceramus* from the Chalk. Of the 61 fragments supposed to be distinct, more than half still remain undetermined. Probably many of these may yield additional information when further studied.—H.W.]

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## V.—NOTES ON THE BRIDLINGTON CRAG AND BOULDER-CLAY.

By F. A. BEDWELL, M.A., F.G.S., F.R.M.S.

IT is with great pleasure that I add a few remarks to Mr. Lamplugh's paper. His observations are, I think, highly important, and will, I anticipate, be found to do great credit to the intelligence and powers of observation of a very young and entirely self-taught naturalist.

The story of the Bridlington Crag is given in a paper by Dr. S. P. Woodward in the GEOLOGICAL MAGAZINE, Vol. I. p. 49 (1864), which affords details of the various notices and a valuable list of shells in the Bridlington Crag, with an instructive table, in which the list is compared with that of the Coralline, Red, and Norwich Crags, and with the glacial deposits and living specimens.[1]

My own observations on this deposit began in 1875; in March of that year I found a *Tellina* about high-water mark in a Blue glacial clay forming the surface of the shore close to a cut leading down on to the North Sands, and called Sand Lane, near an Hotel called the Alexandra. The actual cliff where the bed was seen in 1821 and 1835 has long since been washed away. That cliff lay about 150 feet to the eastward of a house now occupied by me, and called Fort Hall. This house stands 300 yards north of the pier, on the edge of a cliff, now bricked up with, and concealed behind, a wall erected to preserve the house. As the spot where I found the *Tellina* was over 500 yards to the north of my house along the sands, I was led to conclude that the Bridlington Crag was of a much more extended character than was suggested by geological writers. In the same month I also found some of the same fossil *Tellinæ* on the South Shore thrown up on the sand by the waves, and fastened together by the Byssus threads of living mussels. These had come from the mussel-beds which extend widely over Bridlington Bay at about a quarter of a mile from the shore, and their presence suggested an extension of the Crag-bed considerably to the eastward and southward. At this time, March, 1875, there was no exposure of the clay on the north or south shores of any extent, but in December, 1875, a south-east gale one night stripped off the sand on the North Shore before my house, and I then saw the remains of the true Crag-bed lying on the shore, and occupying as a horizontal section the area which had been once covered by the cliffs now destroyed, and in which the Crag was

[1] The bear's tooth referred to in Dr. Woodward's paper is now in my possession.

originally seen. I obtained a collection of shells and black nodules from the spot, but none of any fresh species. What I considered of most importance was, that I saw the horizontal section of the beds for myself, and observed that the complete bivalved shells, which were numerous, lay horizontally and showed no signs whatever of disturbance, and I concluded then, and still think, that they died and lived very near to where I found them. The beautiful *Nucula Cobboldiæ* in particular occurred, with both valves perfect, while, delicate as it is, it had never been assailed by any force so applied as to injure its exquisitely ornamented shell. The *Pholas crispata*, which was exceedingly plentiful, was found invariably as a double shell, and indeed I have never seen a specimen yet of a single separated valve of that shell. *Astarte borealis* too, and *Saxicava*, were frequently double.

The order and position of the bed on the North Sands as thus seen by me in December, 1875, exactly corresponds with that above given by Mr. Lamplugh for the southern extension. On the North Shore it lies *on* the Blue clay, that is, the 'Basement' clay of Wood and Rome. It lies *below* the snuff-coloured laminated clay, while the 'Purple' clay of Wood and Rome lies *above* the snuff-coloured clay. As seen by me on the North Shore, the Crag sand, which was very marked in its character, lay in mottled streaks in the Blue clay. I traced it over a horizontal area of about 20 by 100 yards. The Blue clay was always quite distinct, and there were no signs of a transitional bed from one to the other. The fossils were mostly met with in the sand, but I found a *Cyprina Islandica* in the 'Basement' clay itself three to four inches below the exposed surface, and I feel quite satisfied that it lay in a 'natural' bed and not in a 'derivative' one. The bed on the North Sands, as described by Mr. Bean, and when seen in vertical section by him in 1835 in the exposed cliff side, was "a heterogeneous mass only a few yards long and *as many high*, composed of sand, clay, marine shells, and pebbles of every description."[1] This description gives the bed a considerable perpendicular altitude; but whether that portion of the bed as so seen was the result of local ocean "sweepings" or not we cannot now be certain; but, from what I was told by a local geological collector, now dead, the late J. Tindall, who saw the bed, I am inclined to think that it was so, for he stated quite positively to me that at the spot seen by Bean there was no glacial clay whatever above the bed of sand in which the fossils were found—this might indicate a creek or recess in the then shore-line into which the accumulation had been drifted. Prof. Sedgwick, too, in 1821, says he might easily have filled a wheelbarrow with specimens, thus again denoting a pile of shells heaped near together.

The independent observation which I made in December, 1875, was soon brought to an end, as the sand rapidly returned and hid the bed again, and it has not been exposed since. I made no use of the observations thus obtained, because, in the face of Mr. Tindall's information, I was much perplexed as to the true stratigraphical

[1] See Bean, quoted by Woodward (*l. c.*).

position of the bed; for while he most positively assured me that there was no Purple clay, or, indeed, glacial clay of any kind at all over the bed, and also that it lay above the snuff-coloured clay, Wood and Rome, on the other hand, placed the bed in the Purple clay itself, and yet my own observations placed it below the 'Purple' clay and the snuff-coloured clay, and on the 'Basement' clay. At the same time, the extent of the bed, as shown by the specimens found by me at a distance, formed an additional difficulty. But Mr. Lamplugh's observations have cleared up all my doubts on these points, and the recent exposure on the South Sands, which I have inspected, quite confirms my observations on the North Shore in 1875. I go further than Mr. Lamplugh, and I think the South Sands Beds are conterminous with the Northern, and that the snuff-coloured clay is a leading guide on this point.

But the incident which strikes me as most remarkable and instructive in Mr. Lamplugh's observations is the fact that he has found fragments of Crag shells extensively scattered, through the Purple clay, over so large an area. Many of such fragments at Bridlington actually lie in the cliff as high as twenty feet above the horizon in which they must have been originally deposited, if we refer them originally to the horizon of the true Crag bed. I could hardly believe his statement when I first heard it, because all appearances were against it, and because I had myself hunted the Purple clay for shells in 1875, and quite failed to find any. That Mr. Lamplugh is right, there is no doubt, and my eyes, once educated by him to find them, soon discovered the fragments. As a rule, they are very small, and easily overlooked by any person who does not read a cliff with such exhaustive and intelligent exactness as characterizes Mr. Lamplugh's observations. I have since myself found a *Tellina*, nearly perfect, in the Purple clay of the cliff, quite twenty feet above the true Crag-bed horizon, and about 600 yards distant from the spot where that bed was first seen.

The association of these fragments of shells with the Purple clay seems to me to point to two distinct 'sets' or 'tides' of glacial action meeting on the area which the Purple clay occupies, because, while the *boulders* in the Purple clay evidence a movement from the north-west, these fragments, to my mind, are evidence of another movement from the eastward. I cannot at present agree with Mr. Lamplugh's implication that these shells represent a Crag deposit removed by the glacier that brought down the Purple clay, because, if ever these shells had got incorporated into the glacier, they would, like everything else of so weak a structure that it removed, have been comminuted by it, and converted into the finest débris, digested, in fact, by its masticating grasp, and I should attribute the presence of the shells rather to the long continuance of a process of 'churning,' that churning being the result of opposing forces, one from the land of a glacial character, and the other from the sea opposing the glacier with an accumulation of shore or broken ice.

The absence of boulders of any magnitude in the 'Basement' or blue clay, and the fine quality of that clay, speaks of a glacier which had either no boulders to drop, or which had dropped the larger part before it reached the spot where the blue clay is deposited.

The 'Crag' shells lying on the blue clay speak of a sea deep enough to be removed from the access of ice forces.

The presence of the 'sand' speaks of the proximity of a creek, or sea-beach, or bay unassailable by ice forces (compare Speeton shell-bed referred to subsequently).

The 'snuff'-coloured clay above the Crag, with its laminations and remarkable tenacity, speaks of a glacier very powerful as a comminuting agent, and of a transporting force which had left all large particles of every kind behind it, and of gravity acting without interference.

Then the 'Purple' clay represents a further variety of ice action, which observers experienced in ice forces as exhibited in Arctic Seas will alone be able to realize. But, as above suggested, I should refer it to a tidal churning, a repeated freezing and thawing, and to shore-ice just beginning to attack the débris of a retreating glacier, and in doing so disturbing the bottom on which that débris lay, and thus tearing up the Crag shells here and there, and even possibly in places depositing them in a heap above the 'snuff'-coloured clay.

That the shore-line has been very gradually and extensively elevated we see from the cliffs, and the Crag must clearly have been raised several fathoms to reach its present horizon on the shore-line, and this also supports the views expressed above.

Over the 'Purple' clay, and here and there in the 'Purple' clay, come the 'gravels,' roughly stratified in places, but representing a restless force which was perpetually changing the direction in which it acted, and continually interfering with gravitation. These gravels seem to suggest shore ice predominating, and having the coast-line to itself, because, while the entire absence of all shells from these gravels is very striking, the presence of minute fragments of coal clustering together precisely as now seen on an ordinary sand beach, is equally noticeable. Particles of coal cling together when washed up by the sea on a shore-line with a pertinacity which has always struck me as most remarkable, and you see numerous beds of such fragments in these gravels, denoting a 'vehicle of flotation,' so to speak. You do find coal in the 'Purple' clay, but it is in large pieces, so that in these gravels I see water action of some kind combined with a force inimical to life.

The whole line of action would thus represent a gradual elevation of the land and a retreat of a glacier.

Closely connected with this subject is the interesting bed of recent fossils found by Messrs. Bean and Phillips in the Speeton Cliffs, 100 feet above the shore-line.[1] I have examined this bed, which is almost entirely concealed (masked) by a layer of 'Purple' clay that has dripped down from above and covered the face of the bed an inch thick. On picking this off, a beautiful bed of sand is disclosed about twenty feet deep. I traced the bed to its foundation, and at its basement found, in addition to the shells mentioned by Phillips,

[1] Phillips, p. 101.

a large supply of mussels. This bed in my opinion was like the 'Bridlington Crag' at the base of the 'Purple' clay. The existence of fragments of shells in the representative of the 'Purple' clay along the shore as far north as Whitby, and pointed out by Mr. Lamplugh, is most remarkable, and suggests a wide extension of such shells antecedent to the deposition of the 'Purple' clay, and he will by further researches at Speeton, Dimlington and other localities, be able hereafter to throw additional light on a subject to which his present paper has given a new and special interest.

## NOTICES OF MEMOIRS.

On the Thermal Sources of Carlsbad, North-west Bohemia. By F. von Hochstetter and F. Teller. (Proceedings Imper. Acad. Vienna, March 14, 1878.)

THE recent demolition of a house has led to the discovery of a remarkable geological fact—the existence of a peculiar zone, about fifteen to twenty mètres broad, between the steep pyritose granite, with frequent veins of hornstone, on which the Town Tower stands, and the similarly pyritiferous granite cropping out beneath the terrace of the Schlossberg. This zone is filled up with a breccia of granite and hornstone, with thermal waters circulating everywhere within its fissures, and depositing on their inner surfaces crusts and veinules of aragonite, some of them 1½ mètre thick. The temperature of the whole zone is high, on account of the warm water and steam issuing out of every cleft and crevice.

The situation of this breccia band, as also the direction of the veins of hornstone in the granite, leads to the conclusion that this thermal zone extends northwestward to the *Schloss-Brunnen*, and southeastward to the *Sprudel* Region proper, in the bed of the River Tepl. Thus the views announced in 1856 by Professor von Hochstetter, who affirmed that the chief *Sprudel* fissure lies in a N.W.—S.E. direction, have again been confirmed. Count M.

## REVIEWS.

The Geology of Sussex; or the Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex. By the late Frederick Dixon, Esq., F.G.S. New Edition. Revised and Augmented by T. Rupert Jones, F.R.S., F.G.S., etc., Professor of Geology, Staff College, Sandhurst; aided by Professor Owen, C.B.; Sir Philip Grey-Egerton, Bart., M.P.; and Messrs. Carruthers, Davidson, Etheridge, John Evans, D.C.L., John Morris, Newton, Sollas, Topley, E. H. Willett, H. Willett, H. Woodward, T. Wright, M.D., and other scientific friends.
4to. pp. xxiv. and 470. Illustrated by 64 Plates and 74 Woodcuts. Brighton: William J. Smith, 1878.

IN the early half of this century County Histories were greatly in vogue, and as geologists are not altogether free from a tendency to follow the prevailing fashion of the time, we find such books appearing as "Phillips's Geology of Yorkshire;" "Woodward's Geology of Norfolk;" "Mantell's Geology of Sussex;" "Mantell's

Geology of the Isle of Wight;" and "Dixon's Geology of Sussex." Of these geological histories of English Counties, that of Dixon is certainly among the most important hitherto attempted.

It is seldom the good-fortune of a deceased author to enjoy such advantages for his unpublished work as fell to the lot of the late Mr. Frederick Dixon.

That gentleman died before the completion or issue of the first edition, which was brought out under the auspices of Professor Owen, who kindly acted as Editor. The second edition enjoys the advantage of the editorial direction of one who was long distinguished as the Editor of the Quarterly Journal of the Geological Society of London, and has since prepared for the press the beautiful memorial work of Messrs. Lartet and Christy, "*Reliquiæ Aquitanicæ*"; and that remarkably compendious volume "The Arctic Manual," a most exhaustive work on polar geology and physiography.

The new edition of Dixon's Geology of Sussex, just issued at Brighton, promises for the work a fresh lease of life and a long list of appreciative readers and subscribers. For the new edition is not a mere corrected reprint of the old work, but a new work altogether.

It is gratifying to see again on the title-page the names of Professor Owen—the Editor of and a large contributor to the first edition, which appeared in 1850, and Sir Philip Grey-Egerton, also one of the original contributors; whilst a goodly list of new, but well-known, names of geological writers has been added to the title-page, and their contributions incorporated in the volume itself.

The leading feature of the first edition was its palæontology; this has been greatly strengthened by the addition of much new and important material.

For example: in Fossil Botany we have two valuable contributions on Tertiary Plant-remains, and on the Flora of the Cretaceous formation, by W. Carruthers, F.R.S., F.L.S.

The Protozoa and Rhizopoda have also received attention. The Foraminifera from the Tertiary and Cretaceous deposits being carefully described by Professor T. Rupert Jones, F.R.S.

The *Ventriculites* form the subject of a special article by Mr. W. J. Sollas, M.A., F.G.S. The typical Cretaceous Invertebrate Fossils of Sussex are more or less fully described and figured. Their illustration occupying forty-three plates—of these, nineteen plates have been added since the first edition of Dixon, being the original figures and plates from Mantell's Fossils of the South Downs.

The Tertiary Mollusca have been brought up to date by references to the works of F. E. Edwards and Deshayes, and by copious lists of characteristic species. The Post-Tertiary Mollusca have also been carefully noticed.

The Echinoderms have been partly revised by Dr. Thos. Wright, F.R.S.E., F.G.S.

The Crustacea more fully by Dr. H. Woodward, F.R.S., F.G.S., who also describes and figures a new Cretaceous form.

The Fossil Fishes of the Tertiary and Cretaceous formations have been revised by Sir Philip Grey-Egerton, Bart., M.P., F.R.S., and

Mr. E. T. Newton, F.G.S., who have added much valuable additional matter to this section of the work.

Professor Owen has revised the Reptilian portion throughout, and added a note on Iguanodon (p. 428).

The Antiquities—both Historic and Pre-historic—have been carefully revised, and also somewhat added to. The Coins, etc., by Dr. J. Evans, F.R.S., and C. Roach-Smith, Esq., F.S.A. Whilst the discovery of a Palæolithic implement at Portslade, and an account of the Sussex Hill-Forts and Flint-implement Factory at Cisbury, is given by Mr. Ernest H. Willett, F.S.A.

The weakest part of the original work was probably the geology. This is now entirely obviated. The opening chapter gives an excellent and clearly-written account of the general geographical and geological features of the County of Sussex by the Editor, Professor T. Rupert Jones, F.R.S.; illustrated by a charming map of the County coloured geologically (measuring 28in. by 10in.), with a section from the English Channel to the Isle of Sheppey, by W. Topley, F.G.S.

The Newer Tertiary, Post-Tertiary, or Quaternary beds of Sussex are fully described after Godwin-Austen, Prestwich, Mantell, Bell, and others.

The Tertiary beds of Bracklesham, etc., in addition to F. Dixon's description, have added to them the accounts of Dr. Bowerbank and the Rev. O. Fisher, M.A., F.G.S.

The Newhaven Beds are described after Professor Prestwich, F.R.S., and Mr. W. Whitaker, B.A., F.G.S.

The chapters on the Chalk Formation have been entirely revised and modified according to our present knowledge.

The description of the Wealden and other strata of East Sussex forms an entirely new chapter: whilst Mr. Topley's account of the Sub-Wealden trial boring, and its results to science, will form a permanent memorial of that interesting attempt to solve the geological structure at the base of the Wealden series. Besides the large number of entirely new chapters which have been added to the work, no page can be referred to which has not been enriched by some new facts carefully and correctly placed by the judicious Editor. Every author writing on subjects bearing upon the geology or palæontology of Sussex since 1850, will be gratified to find his observations quoted in their appropriate chapter; whilst the copious index renders the work at once easy and convenient for reference.

The Editor, in every case, marks new matter added, giving the authority cited, and so careful has he been, that even a word inserted is put into square brackets to show that it is new.

We may fairly congratulate Mr. William J. Smith, the Brighton publisher, who has ventured upon the undertaking of this New Edition of "Dixon's Geology of Sussex," and we can but hope that the task so ably carried to its completion by Professor T. Rupert Jones may be appreciated by a large circle of geological friends, not only in the County of Sussex, but throughout Great Britain and abroad, among the many foreign geologists who take a lively interest in English scientific literature. W.

## SIR RICHARD JOHN GRIFFITH, BART.,

LL.D., F.R.S.E., F.G.S., M.INST.C.E., M.R.I.A.

Born 27 September, 1784; Died 22 September, 1878.

In the early days of the present century, Geology, like the "Dark Continent," was but little known, and every man was his own guide in the new science. Roads were few and imperfect, and guides were wanting; whilst barriers of ignorance and prejudice blocked the way at the very outset.

Now all is changed—the pioneers of our science have done their work grandly and well, and prejudice has given place to favour and public recognition. But by far the larger number of those grand original workers and thinkers, to whom we owe so much, have laid down their hammers and pens and have passed away.

To the names of William Smith, Greenough, MacCulloch, De la Beche, Scrope, Lyell, Sedgwick, Murchison, Phillips, must now be added that of the venerable Sir Richard Griffith.

Born in Hume Street, Dublin, on the 27th September, 1784, Richard Griffith was, at an early age, placed by his father in the best public school in that city; and later on, in 1797, he proceeded with his studies under the tuition of the Rev. Mr. Moore, of Donnybrook. As soon as the completion of his education permitted, he obtained a commission in the Irish Artillery; but when, after the Act of Union had passed, the Irish Artillery became merged in the British forces, his father conceived it to be more to his son's advantage that he should resign his commission and devote himself to Civil Engineering and Mining. In order to prosecute his studies more successfully, he visited Cornwall, where he had the good fortune to obtain an early reputation for acumen by discovering at the Dalcoath mine rich ores of nickel and cobalt, which had previously been rejected as of no value. Lord Dunstanville, the owner, was so delighted at the discovery, that he proposed to make Lieutenant Griffith general manager and superintendent, but he modestly declined, preferring to extend the range of his knowledge by a careful survey of the mining districts of Derbyshire, Yorkshire, and Northumberland. Thence he continued the pursuit of practical mining and surveying into Scotland, studying for a time in Edinburgh under such eminent men as Sir James Hall, Professors Playfair, Jameson, Hope, and others. Here his rising abilities were held in such high estimation, that, at the early age of 23, he was unanimously elected a Fellow of the Royal Society of Edinburgh. In 1808 he returned to Ireland, and commenced his professional career by the publication of a work, under the auspices of the Royal Dublin Society, entitled "Geological and Mineralogical Examination of the Leinster Coal-field," which was completed in 1814. In 1809, the Commission appointed to inquire into the practicability of draining and improving the peat-bogs and mosses of Ireland, selected Mr. Griffith to be one of their engineers. In 1812 his Surveys and Reports were published by authority of Parliament. He was at this time appointed to succeed the late eminent Chemist and Mineralogist, Richard Kirwan, as Inspector-General of His Majesty's Mines in Ireland.

After the famine in the South of Ireland, in 1822, he was employed by the Marquis Wellesley, then Lord-Lieutenant, to improve and construct roads in the counties Cork, Kerry, and Limerick, a task which, had it been Mr. Griffith's sole achievement, was carried out so successfully as to merit the highest praise. Whilst engaged on this laborious undertaking, he constructed two hundred and fifty miles of new roads through a mountainous district, previously quite inaccessible, and the favourite resort of "Whiteboys," who made it their stronghold, and defied the laws.

Before the Ordnance Survey was established, Mr. Griffith was appointed General Boundary Surveyor, and so long ago as the year 1812 the first outlines were attempted of one of the most valuable and important works with which his name is identified, namely, the preparation of a Geological Map of Ireland. No labour seemed to Griffith too great in order to carry out this great work satisfactorily, and also its subsequent revision; indeed, throughout his life, he never lost his interest in it. Four editions of it were published, the latest of which was issued in 1854.

In 1828 he was appointed Commissioner for the General Survey and Valuation of Rateable Property, while his services were used by the Government in connexion with various other commissions, such as the Shannon Commission, etc. In 1848 he was appointed Deputy Chairman of the Board of Works (Dublin), and in 1854 he became Chairman, an office which he held until his death, although relieved of its active duties. It should be mentioned that he was twice elected President of the Geological Society of Ireland, and took a very active part in its proceedings, and in promoting the study of geology in his native city.

Dr. Griffith records that the Meeting of the British Association in Dublin in the year 1835, gave a fresh impulse to his labours, and in 1838, Major Larcum, R.E., of the Ordnance Survey Office, Dublin, constructed for him an entirely new Topographical Map of Ireland on a scale of four miles to an inch, "the most accurate Map of Ireland that has hitherto been published." (See Quart. Journ. Geol. Soc. 1854, vol. x. p. xx.) It was on this map that Dr. Griffith finally laid down the fourth and revised edition of his stratigraphical colouring and geological boundary lines, and the first copy of which he exhibited to the Geological Society of London in February, 1854. At that Anniversary Meeting the Council awarded Dr. Griffith the Wollaston Palladium Medal, in recognition of his valuable services to geology by the completion of his Geological Map of Ireland.

In 1858 Her Majesty conferred a Baronetcy upon him in acknowledgment of his long and valuable public services.[1] One who knew him well, Mr. G. H. Kinahan, M.R.I.A., writes :—"Griffith had extraordinary powers of endurance, memory, and foresight. He usually travelled by night, and after spending the night in a post-chaise would do a hard day's work in the field. Scarcely twenty years

[1] Much of the foregoing is taken from the Dublin *Daily Express*, Sept. 27, 1878.

ago he walked over the Dingle Mountains with a party of young men, yet Sir Richard, then over 70 years of age, was as active as the youngest, and endured a pitiless downpour of rain in his swallow-tail coat perfectly unconcerned."

"Like Sir William Logan in Canada, wherever Sir Richard Griffith went he made friends, and these, throughout the whole of Ireland, served as an army of amateur helpers, who supplied him with information as to rocks and fossils. He had a wonderful memory for names and places, and could describe minutely each quarry and section in any given locality, long years after he had visited it."

"More than half a century has passed away since Griffith commenced his Geological Map of Ireland. At that time there were no Ordnance Survey sheets to use as a basis on which to lay down his geological work, as bit by bit he made it out and pieced it together. The existing maps were very incorrect, and they had to be corrected, or maps had even to be made, before they could be used.

"One striking feature about the work is that it is all the result of his own personal observations, and none of it was done by guess-work, yet it was all done before a railway existed, and when even good roads were rarely to be met with.

"The period now called Palæozoic had then but three divisions—the centre was 'Old Red Sandstone,' below which all the rocks were called 'Transition,' or 'Greywacke,' and those above 'Carboniferous.'"

[Sir Richard Griffith is said to have doubted the propriety of retaining the so-called "Old Red Sandstone" series as a separate formation in Ireland, believing it to be made up partly of rocks of Silurian age, and partly of those of the Carboniferous period. However this may be (whether in deference to the opinion of other eminent geologists, or partly as his own conviction), he certainly retained the Old Red Sandstone formation on his map.

He refers with evident confidence to his successful sub-division of the Irish Carboniferous system into a seven-fold series, five belonging to the Carboniferous Limestone, and two to the Coal (Quart. Journ. Geol. Soc. 1854, vol. x. p. xxi.).]

"The tracts which Griffith believed to be Silurian, although coloured as Old Red Sandstone, are the mountainous area about Fintona (Cos. Tyrone and Fermanagh), the rocks of the Curlew Mountains (Cos. Sligo and Roscommon), and the Slieve Moyle rocks (Co. Mayo). Subsequently when Du-Noyer found plants in the Silurians of West Cork, which were pronounced by Salter to be allied to Carboniferous forms, Griffith still adhered to his opinion, and said: 'The plants may be Carboniferous, but the rocks are Silurian.' Plants allied to Carboniferous forms have since been found both by American and Continental geologists in rocks of known Silurian age, so that in all probability Griffith was correct.

"When the late Dr. Oldham had proved the existence of Cambrian rocks in Dublin, Wicklow, and Wexford, Sir Richard Griffith stated that rocks of the same age existed in Donegal and Galway. The Donegal rocks have still to be worked out, but as regards Galway

Griffith was quite correct, for beneath the rocks considered by Prof. Ramsay to be the basal group, equivalent to the English Cambro-Silurians, there are over 7000 feet in thickness of rocks that can only be deemed to be of Cambrian age."—(KINAHAN.)

So lately as the week in which Sir Richard Griffith died, Prof. Edward Hull, F.R.S., the Director of the Geological Survey of Ireland, addressed a letter to him from Glengarriff, informing him that as regards the age of "the Dingle Beds" (which had been referred by Griffith to the Silurian formation and are coloured as such in his Map of Ireland (edit. 1855), but which the officers of the Survey held to be of uncertain age, and had coloured them intermediate between Old Red Sandstone and Upper Silurian), he was now fully convinced "of the correctness of Sir R. Griffith's views regarding the age of the Dingle, Killarney, and Glengarriff Ranges." ("Nature" October 10, 1878, p. 627.) But the venerable geologist never lived to rejoice in this confirmation of his views. History will doubtless do justice to the great merit of his work.

We owe to Sir Richard Griffith a most valuable contribution to palæontology, namely, a "Synopsis of the Characters of the Carboniferous Limestone Fossils of Ireland, by Frederick M'Coy, F.G.S." (Dublin, 1844, 4to. pp. 208, 29 plates; reprinted in 1862, with table of fossils and localities.) This valuable work, containing, in addition to the fossils previously known, descriptions and figures of 450 new species, was prepared and published at the cost of Sir Richard Griffith, and represents the specimens in his own cabinet, collected either by himself or his friends, from the Carboniferous Limestone system of Ireland.

We hope that this valuable collection may find a resting-place in one of the public museums in Dublin.

The following is a list of papers published by Sir Richard Griffith, Bart. :—

Report relative to the moving bog of Kilmaleady in the King's County.—Tilloch, Phil. Mag. lviii., 1821, pp. 70–73.

On the Principle of Colouring adopted for the Geological Map of Ireland. —Dublin Geol. Soc. Journ. ii. 1839, pp. 78–90.

On Mr. Weaver's paper on the Mineral Structure of the South of Ireland.—Phil. Mag. xvii. 1840, pp. 161–179.

On the Geological Relations of the several rocks of the South of Ireland [1839]. —Geol. Soc. Proc. iii. 1841, pp. 136–138.

On the Syenite Veins which traverse Mica, Slate and Chalk at Goodland Cliff and Torr Eskert, to the south of Fair Head, in the County of Antrim.—Trans. Geol. Soc. 2nd series, v. p. 179. Proc. Geol. Soc. ii. p. 223. Phil. Mag. 3 series, viii. p. 559.

On the Geological Relations of the several Rocks of the South of Ireland.—Proc. Geol. Soc. iii. p. 136. Phil. Mag. 3 series, xv. p. 536.

On the True Order of the Succession of the Older Stratified Rocks in the neighbourhood of Killarney and to the North of Dublin.—Phil. Mag. series 3, xvi. p. 161; xvii. p. 161.

On the Geological Map of Ireland.—Rep. Brit. Assoc. 1835, Sect. p. 56.

On the Leading Features of the Geology of Ireland.—Rep. Brit. Assoc. 1837, Sect. p. 88.

On the Geological Structure of the South of Ireland.—Rep. Brit. Assoc. 1838, Sect. p. 81. Karst. u. Dech. Arch. xvii. p. 388. L. u. Br. N. Jahrb. 1844, p. 828.

Statement of the Fossils which have been Discovered in the Several Members of the Carboniferous or Mountain Limestone of Ireland.—Rep. Brit. Assoc. 1842, Sect. p. 51.

On the Distribution of Erratic Blocks in Ireland, and particularly those of the North Coasts of the Counties of Sligo and Mayo.—Rep. Brit. Assoc. 1843, Sect. p. 40.

On the Lower Portion of the Carboniferous Limestone Series of Ireland.—Rep. Brit. Assoc. 1843, Sect. p. 42.

On the Old Red Sandstone, or Devonian and Silurian Districts of Ireland.—Rep. Brit. Assoc. 1843, Sect. p. 46.

On the Occurrence of a Bed of Sand containing Recent Marine Shells, on the summit of a Granite Hill, on the Coast of the County of Mayo.—Rep. Brit. Assoc. 1843, Sect. p. 50.

On certain Silurian Districts of Ireland.—Rep. Brit. Assoc. 1844, Sect. p. 46.

Notice respecting the Fossils of the Mountain Limestone of Ireland, as compared with those of Great Britain, and also with the Devonian System.—4to. Dublin, 1842.

A Synopsis of the Characters of the Carboniferous Limestone Fossils in Ireland.—4to. Dublin, 1844.

On the Order of Succession of the Strata of the South of Ireland, particularly with reference to the Killarney District, Co. Kerry.—Dublin Geol. Soc. Journ. iii. 1849, pp. 150–160.

On the Lower Members of the Carboniferous Series in Ireland.—Brit. Assoc. Rep. 1852 (pt. 2), p. 46.

On the Copper Beds of the South Coast of the Co. of Cork.—Dublin Geol. Soc. Journ. vi. 1853–55, p. 195.

Explanation of the Principles of Colouring the Geological Map of Ireland.—Dublin Geol. Soc. Journ. vii. 1855–56, p. 294.

On the Sub-divisions of the Carboniferous Formation of Ireland.—Dublin Geol. Soc. Journ. vii. 1855–57, p. 267.

On the Remains of Fossil Plants Discovered in the Yellow Sandstone at the base of the Carboniferous Limestone Series of Ireland.—Dublin Roy. Soc. Journ. i. 1856–57, p. 313.

On the Relation of the Rocks at or below the base of the Carboniferous Series in Ireland.—Brit. Assoc. Reports, 1857, pt. 2, pp. 66-67.

On the Stratigraphical Relations of the Sedimentary Rocks of the South of Ireland, of which the Glengarriff and Dingle Districts are composed, etc.—Dublin Geol. Soc. Journ. viii. 1857–60, p. 2.

On the Occurrence of *Posidonia Becheri* in the Calp of Rush, Co. Dublin, and of *Posidonia lateralis* in the Carboniferous Slates of Kinsale, Co. Cork.—Dublin Geol. Soc. Journ. viii. 1857–60, p. 75.

An Additional Permian Locality, Co. Tyrone.—Dublin Journ. Geol. Soc. viii. 1857–60, p. 173.

The Localities of Irish Carboniferous Fossils, arranged Stratigraphically, etc.—Dublin Geol. Soc. Journal, ix. 1860–62, p. 21.

On the Boulder-Drift and Esker Hills of Ireland, and on the position of the Erratic Blocks in the country.—Brit. Assoc. Reports, xli. 1871, (Sect.) pp. 98-100.

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Professor Robert Harkness, F.R.S., F.G.S., late of Queen's College, Cork.—This eminent Geologist died suddenly, from heart-disease, in Dublin on Oct. 3rd.—*Nature*, Oct. 10th, 1878.

Mr. Thomas Belt, C.E., F.G.S.—The death of this excellent Naturalist, Observer, and Geological Writer, is announced in *Nature*, Sept. 26th, 1878.

We hope to publish Memoirs of both the above geologists in the December Number.—Edit. Geol. Mag.

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Errata.—The Rev. Maxwell H. Close requests to be allowed to note the following corrigenda in the last Number of the Geol. Mag., for which he is not responsible. P. 452, line 15, *for* "probable," *read* "improbable"; line 18, *for* "molecular," *read* "molar"; p. 453, line 6, *dele* "at that time"; p. 454, line 1, remove inverted commas from sentence following "figure." Mr. Close says, "I did not read out the note; it contains a strange blunder of mine, but unfortunately I forgot to tear it away when giving the MS. to be printed."

THE

# GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. V.

No. XII.—DECEMBER, 1878.

## ORIGINAL ARTICLES.

### I.—A Possible Explanation of the North Devon Section.

By Prof. Edward Hull, M.A., F.R.S., F.G.S.;
Director of the Geological Survey of Ireland.

WHILE engaged this autumn in reinvestigating the relations of the "Dingle Beds" and "Glengarriff Grit Series" to the Silurian rocks below, and the Old Red Sandstone above, in the South-West of Ireland, my mind naturally reverted from time to time to the Devonian district, and the succession of its beds, upon which there has recently been so much discussion, and to which the late Professor Jukes devoted so much time and labour. With him I agree in believing that the key to the solution of the Devonian problem is to be found in the structure of the South of Ireland, though with reference to the actual explanation which he proposed, I can only see my way to a partial concurrence.

The full and lucid descriptions of the formations of North Devon which we possess are sufficient to enable any one acquainted with the rocks of the South of Ireland to recognize representative beds, even if they may not have visited Devonshire itself. For those who are in this position there are the writings of authors, of which Mr. Etheridge has given a complete summary, and, more recently, those of Professor Jukes and Mr. Etheridge himself.

Pending a personal visit, I venture to offer a contribution towards the solution of the Devonian problem, which, to some extent, meets the views of recent writers, though somewhat different from any yet proposed. And, in the first place, I may observe that, as far as investigations have yet gone, they have not resulted in discovering the great east and west fault which Jukes supposed to range across North Devon, repeating the red rocks and overlying slates and limestones of Foreland, Lynton, and Ilfracombe. On the other hand, we have the elaborate investigations of Etheridge, both palæontological and stratigraphical, all going to show that there is an approximately unbroken sequence from the Quantock and Lynton sandstone on the north into the Carboniferous beds of the centre of the country (Quart. Journn. Geol. Soc. vol. xxiii.).

With reference to the bearing of the structure of the South of Ireland on that of Devonshire, I have come away from the examination of the rocks in the former district strongly impressed with two or three leading conclusions.

*First.*—That the "Dingle beds" (Glengarriff grits, etc.) belong in all probability to the Upper Silurian series, a view maintained by Sir R. Griffith, Mr. John Kelly, and others, including several of my colleagues of the Geological Survey of Ireland.

*Secondly.*—That not only in the Dingle promontory, but everywhere in the South of Ireland, these Upper Silurian beds are separated by a wide gap (represented by denudation and unconformity) from the true Old Red Sandstone; and *thirdly*, that the Old Red Sandstone is conformable to the overlying Lower Carboniferous series;—a view generally accepted amongst Irish geologists.

With these Upper Silurian beds ("Dingle beds and Glengarriff grits"), consisting of conglomerates, red and green grits, and purple slates of great thickness rising into the highest elevations in Ireland, striking generally eastwards until they pass unconformably below the Old Red Sandstone of Cork and Waterford, the question arises, may we not expect to find them represented in the Devonshire Section? This, to my mind, seems in the highest degree probable, to say the least of it. Then, again, another question suggests itself:—May there not be some beds in the Devonshire Section which, in that region, occupy the gap between the Upper Silurians and the true Old Red Sandstone in the South of Ireland? If so, what part of the series would they represent? Clearly, beds older than the "Upper Old Red Sandstone," which underlies conformably the Lower Carboniferous beds, and newer than the Upper Silurian; that is to say, beds in the position of the Marine Devonian beds of Devonshire, including the "Lynton Slates" and Ilfracombe and Mortehoe groups.[1]

Now, the base of this fossiliferous Marine Series is evidently and admittedly "the Lynton Sandstone" (Foreland group). A series of unfossiliferous hard red and green sandstones, or rather *grits*, with some slaty beds, of which the base is not seen, and which is overlaid by the Lynton slates, full of marine fossils. Jukes describes them in terms strictly applicable to the Glengarriff grits and slates of Kerry, viz. "as thick massive grits of green and red colours, with purple slates, the whole being similar to many parts of the Old Red Sandstone of the South-western portion of Ireland,"[2] by which he means the "Dingle Beds" or "Glengarriff Grits," by him supposed to be "Old Red Sandstone." Of the beds to which Mr. Jukes refers there can be no doubt; for when he wrote the above, great uncertainty prevailed regarding the real age of these beds. This uncertainty is now nearly removed—and geologists in this country are coming round to the views of the late Sir R. Griffith stated

[1] I use the terms adopted in Woodward's "Geology of England and Wales."

[2] Additional Notes on the Grouping of the Rocks of North Devon and West Somerset, p. 9, Dublin, 1867.

above—that the Dingle Beds and Glengarriff Grits are really the highest members of the Upper Silurian Series, and altogether disconnected from the true Old Red Sandstone. To this question I hope to return on a future occasion.

Reverting, however, to the Devonshire section, I must also assume that the "Pickwell Down Sandstones" are the representatives of the true "Old Red Sandstone" of the South of Ireland. They are described as consisting of red micaceous sandstones, shales, and conglomerates, a description which would answer fairly well for the formation representatives of which I suppose them to be. Mr. Etheridge calls it the "Upper Old Red Sandstone," and possibly the uppermost beds at the junction of the "Baggy and Marwood slates (Cucullæa Zone)" may represent the formation of this name in the South of Ireland ("the Yellow Sandstone" of Griffith) with *Coccosteus*, *Anodonta Jukesii*, and *Adiantites Hibernica*. Jukes mentions some beds near Drayton and Slade, which strongly reminded him of the Kiltorcan beds of this stage in county Kilkenny. It will probably be found on a careful resurvey of North Devon, that the Pickwell Down Sandstones are somewhat unconformable to the underlying beds.

Assuming the identity in position of the Pickwell Down Sandstones with the Old Red Sandstone of Ireland, it follows that the overlying Marwood slates and Pilton Beds, consisting of slates, sometimes calcareous, with bands of limestone and sandstone, characterized by *Cucullæa trapezium*, etc., are the representatives of the "Lower Carboniferous slate and Coomhola grits" of the South of Ireland; and in this identification, I have much confidence that Jukes was perfectly correct. If anything was required to confirm it, we have the plant evidence in the presence of *Lepidodendron* and *Calamites* in Sloly quarry. The general representative sections of the rocks in the South of Ireland and in North Devon, according to the above interpretation, would therefore be as follows (see table at the end of this article, p. 532) :—

Should it ultimately appear that this classification is correct —or approximately so—it will be found to confirm the views of those geologists who consider that there is a general ascending series from the Coast of North Devon, beginning with the Foreland and Quantock Hill group, and terminating with the Culm-measures and Barnstaple Beds. On the other hand, it will confirm Jukes's views regarding the Carboniferous age of the so-called "Upper Devonian Beds" from the Baggy and Marwood slates upwards, and also his determination regarding the age of the "Pickwell Down Sandstones." It also explains the unconformity between the Old Red Sandstone and "the Dingle Beds"—so remarkably prominent in the Dingle Promontory—and it determines the relations between the Marine Devonian Beds and the Old Red Sandstone in Devonshire. In offering the above observations towards the solution of the question, and pending a personal inspection of the North Devon beds, I would, meanwhile, invite the opinion of those geologists who have the advantage of knowing Devonshire already.

Suggested Comparison of the Succession of Formations in North Devon and the South of Ireland:—

Descending Series.

| | North Devon. | South of Ireland. |
|---|---|---|
| Lower Carboniferous Beds (Marine). | *b. Pilton and Barnstaple Beds.*—Calcareous sandstones, grey shales and slates with nodular limestones. Fossils—Marine.<br>*a. Baggy and Marwood Slates.*—Slates and sandstones with *Cucullæa*, etc. | *Lower Carboniferous Slate* and "Coomhola Grits."—Grey and olive green slates and grits with calcareous bands. *Cucullæa* and other fossils. |
| Old Red Sandstone (Freshwater or Lacustrine). | *b. Drayton and Slade Beds.*—Greenish and yellowish sandstones (passage beds). | *b. Upper Old Red Sandstone* ("Yellow sandstone, Griffith").—Yellow and greyish flaggy sandstones, with *Anodonta Jukesii*, *Adiantites*, etc., and fish. |
| | *a. Pickwell Down Sandstone.*—Red micaceous sandstones, shales, and conglomerates. | *a. Old Red Sandstone.*—Red and brownish-red sandstone with bands of shale and conglomerate at base. |
| Devonian Beds. (Marine). | *d. Mortehoe Group.*—Grey and purple glossy slates, etc.<br>*c. Ilfracombe Group.* — Shales and slates with limestones, with *Stringocephalus*, etc.<br>*b. Hangman Grits.*—Red and grey grits, shales, and sandstones.<br>*a. Lynton Slates.* — Gritty slates, shales, and sandstones, with fossils. *Spirifera*, *Orthis*, *Fenestella*, *Bellerophon*, etc. | Not represented in Ireland. Great gap and unconformity at this stage. |
| Upper Silurian (?) | *a. Linton Sandstone* (*Foreland Group*). — Reddish, green, and purple grits and slates.—Plants? "Fucoids," and Annelid burrows only. | *a. Dingle Beds and Glengarriff Grits.* — Greenish Grits, red and purple slates and conglomerates. Plant-like markings and Annelid burrows. |

## II.—Notes on the Geology of the Neighbourhood of Aberystwyth.

By Walter Keeping, B.A., F.G.S.;
Professor of Geology in the University College of Wales.

In England and Wales there is scarcely any area whose geological structure is so little known as the neighbourhood of Aberystwyth. Every year a stream of geologists passes through the northern parts of the Principality, through the varied old-volcanic districts of Snowdon and Cader Idris, and the rich collecting grounds of the Berwyns: and another such stream takes its course to the southern borders along the far west Pembrokeshire coasts, being guided by the careful work of Dr. Hicks. The border counties too are in many places attractive enough, for there it was that Murchison first saw the order of the Silurian rocks, and there also the best-preserved fossils are found. Llandeilo, Builth, Woolhope, May Hill, Malvern, and Wenlock have long yielded rich harvests to palæontologists.

These several districts form the boundaries which, together with the sea of Cardigan Bay, make up a complete zone enclosing the large area of Mid Wales—an area which is very commonly regarded as a wilderness to the geologist, and a desert to the palæontologist. Nowhere in this country are fossils abundant, and the rock-beds are in places marvellously contorted. To study this group of Mid Welsh rocks, we could not do better than to make Aberystwyth our head-quarters, and thence traverse the country in various directions.

First, taking a walk along the shore either to the north or south of the town, the cliffs offer a splendid view of the Aberystwyth group —a great series of bedded rocks in such violent twistings and puckerings as astonish even the most unobservant of people. I know of no better place throughout England or Wales for observing these rock contortions.

*Faults and Joints.*—The few dislocations or *faults* seen along the coast are very small; for example, those just south of Aberystwyth Castle, and again between Aberystwyth and Clarach; but larger faults, mostly in an east and west direction, are doubtless indicated by the many lead veins to the west.

The rock structure known as *jointing* may be well studied in this neighbourhood. A glance at a quarry in any rock will show that the rock material is not all in one solid mass, but is divided up into blocks, sometimes very regularly, sometimes quite irregularly, so that masses may be removed with the wedge and lever without ever breaking across a stone. Such natural planes of division are known as joints. The extent of these joints varies greatly; at Allt Wen, south of Aberystwyth, some very fine examples are seen cutting vertically and cleanly through the rocks, so that in those places where they have been exposed by landslips, which are frequent, they stand out like huge walls of well-built masonry. We may see them running thence straight down the cliff and continuing their course across the shore out to sea.

At the other extreme we have small and frequent jointing, hard to distinguish from cleavage, as is seen in some of the grit-beds near Llanilar. One cannot detect any such regular persistency in the direction of the lines of jointing as we shall afterwards find in the case of cleavage; on the other hand, there is a more intimate relation between the jointing and the sloping of the rock-beds. Some of the hard sandstones of Plynlimmon are jointed into rude columnar masses.

*Rock varieties.*—The rocks of Mid Wales are of few kinds, and they are remarkably similar throughout the district. Beds of grit of that characteristic Cambrian type mixed with clayey material known as Greywacke (originally a muddy sand), sometimes coarse grits, hard sandstones, and occasionally a pudding-stone or conglomerate bed (originally pebble beds), are the forms in which the ancient sandy deposits occur, whilst the clay deposits are now found as irregular shale, mudstone *rab* (a mudstone breaking into small fragments when exposed), *wrack* (a coarser larger form of *rab*), pencil rab (breaking into long fragments—as seen under Allt

Wen), clay-slate, a coarse black slate, and "Bastard" slate. Many varieties of each of these may be collected, and amongst these varieties we will first notice the frequent presence in them of that golden or brassy mineral Iron Sulphide. This may be found in nests under Craiglais, or in cubical crystals further north towards Borth, and up the valley east of Eglwys Fach, where they handsomely stud some of the grits.

Nearly everywhere the coarser grits show some angular brown spots on their weathered portions, and in some places, especially at Mynydd Bach, white crystals are seen. These are, both of them, crystals of felspar, or the remains of such crystals, and they are interesting proofs either of the presence of older igneous rocks close by, from the degradation of which they were obtained, or they may even be the records of volcanos themselves then existing some miles away; for the crystals of felspar are not rounded as they would be if driven for a distance by water-action, but remain still angular. Microscopic analysis shows that much of the felspar belongs to the plagioclase group.

*Fossils and Curious Rock Surfaces.*—Wherever the crystals of iron sulphide occur, we are more likely to find fossils; at the Morben Quarry, near Machynlleth, especially, we find the fossils themselves converted into this bright metallic mineral. Very few of these fossils have yet been recorded. Many years ago, in 1846, Professor Sedgwick found fossil shells at the Devil's Bridge, which were identified by Mr. Salter, and published in the Quarterly Journal of the Geological Society in 1846 (Lond.), and I do not know of any other list. But we need not go so far for organic remains; the quarries around Aberystwyth, at Cefn Hendre Cwm, and Bryn y Mor, themselves yield those fossils called Graptolites (*Graptolites Sedgwicki, G. lobiferus. Rastrites, Dictyonema*, and others), long, slender, toothed, saw-like organisms, each "tooth" being the cell of a small "zoophyte" somewhat less highly organized than a common coral. At the Morbern Quarry beautiful specimens of Graptolites are abundant, including a spiral form. A species of *Diplograptus* may be found in the Llyfnant Valley, near Glandovey; *Dictyonema* and Dendroid Graptolites at the Devil's Bridge; Foraminifera (*Dentalina*,[1] *Rotalia*, and *Textularia*) occur at Cwm Symlog, and shells (mostly *Orthoceras*) at Corris, Taren y Gesail, and Steddfa Gurig. There is a curious branching calcareous organism, which may perhaps be a Polyzoon, found in the quarry at Craiglais, and ranging eastwards as far as Plynlimmon.

But besides these fossils, there are other structures which will force themselves upon the attention of the visitor before he sees such an organism as those we have noticed above. Curious markings, straight, round or irregular; branching, curved, or contorted; and in great variety. Some of these are undoubtedly the tracks of worms; Llampeter, for instance, is noteworthy for its fine specimens of *Nereites Sedgwickii* and *N. Cambrensis*; and

[1] This Foraminifer was first discovered by the Rev. J. F. Blake, M.A., F.G.S. See Geol. Mag. Dec. II. Vol. III. p. 134.

again around Pont Erwyd the beautiful *Nereites Macleani* is quite abundant. All these show clearly the marvellously tortuous tracks of marine worms; centrally we see the depression made by the body, and at the sides are the marks of the numerous lateral "feet" with their bristles. *Nemertites* and other supposed worms are also found.

Others amongst these markings are quite as evidently marine plants—Algæ—seaweeds. There is one well-marked type of these that is particularly noteworthy, consisting of a stalk, sometimes several inches long, from the summit of which branches are given off in a fan-shaped manner. Of this type there are three species—a large, a small, and a medium-sized form. There are also long strap-like seaweeds.

Many others of the queer irregular markings[1] so abundantly found may have had their origin primarily in some organism, or the trace of some organism,[2] to serve as a nucleus around which material has gathered by "concretionary action." We may to some extent explain this concretionary action as a force which causes particles of the same nature to collect together into masses; thus it was that the myriad flinty particles originally in the chalk were dragged together to form flints, so the particles of sulphide of iron came together to form large crystals or nests about Aberystwyth, and so also many of the irregular masses in our local grits have had their origin.

*"Cone in Cone" Nodules.*—Amongst the best-marked of these concretions are the lenticular nodules, which occur in zones, well seen along the coast between Aberystwyth and Borth. They are sometimes so close together as to unite with one another; but good specimens, with circular contours, about 2 in. to 10 in. in diameter, are not difficult to find. The peculiar and pretty structure known as "cone-in-cone" is invariably found over the exterior of these nodules. We may liken this "cone-in-cone" structure to crowds of miniature conical sugar-bags packed one into the other, and all the packets arranged side by side around the stone, moreover every sugar-bag has its sides delicately crimped. The bases of the cones are directed externally, the apices inwards. Single cones may be extracted with the knife, usually about a quarter, or half an inch long, but larger ones are sometimes found. This is not an organism —not a life-structure, and we must look to the results of crystalline forces for some similar appearances to explain its origin. Now ordinary calcspar is often found in a fibrous form, and I have seen layers of such mineral where in some places the fibres run parallel to one another, but in other spots they are directed towards some common point so as to form a cone. Here then was cone-in-cone structure produced by the arrangement of the crystal fibres of calcite.

Carbonate of lime, carbonate of iron, and carbon itself in the form of coal, exhibit this structure, often on a much larger scale

[1] It should be noted that these marvellous surface contortions and other markings, so characteristic of the Mid Wales rocks, are convex on the *under* surface of the flags and grits.

[2] Mostly seaweeds.

than we find it at Aberystwyth. Our specimens probably contain carbonate of iron, for the brown oxide is frequently found colouring exposed weathered specimens.

There is a remarkable contorted structure very common in our grit rocks, which may be well seen in the blocks brought from Ystrad Meurig Quarry, and now forming the stone pier at Aberystwyth. Concretionary action may perhaps explain this in part, but I am disposed to look to water as the more probable agent[1]—the water percolating through the more sandy layers after the deposition of the rock, and so altering the arrangement of the particles.

*Arrangement of the great Rock-masses, and their Age.*—The regular alternation of old sandy and muddy deposits (grit and shale) is very striking around Aberystwith, and for about five miles to the east. Professor Sedgwick called these beds the Aberystwyth Group. Next, further to the east, a great series of slaty rock succeeds—the Metalliferous Slate Group; then at Plynlimmon we reach another grit group (Plynlimmon Group), in thicker beds than at Aberystwyth, and with some quartz-conglomerates (part of the Plynlimmon Group of Sedgwick).

Altogether these several rock groups make up an enormous thickness of strata. An actual measurement of only that part of the series between Aberystwyth and the Devil's Bridge gave us a thickness of over three and a half miles.[2]

Of all these deposits the Aberystwyth rocks are the lowest, for all the beds to the east slope over them, just as the lines here drawn towards *B* incline over those nearer *A*. *A.*  *B.*

As we walk to the north or to the south, we shall find again that the rock deposits slope away from, and are therefore newer than, those at Aberystwyth. Even to the west, too, the beds slope away seawards, as may be seen when we walk along the shore, or notice the cliff sections. So that Aberystwyth is the centre of what is known to geologists as an *Anticlinal axis*—the axis of a huge dome of rock-masses. The slope to the north and to the south is much less steep than to the east, so that an almost north and south line of outcrop has its axis running through Allt Wen, Aberystwyth, and over Constitution Hill on to Clarach.

The exact geological age of the Aberystwyth rocks cannot yet be fixed. That they are extremely old is clear enough, for just as we see in the little diagram above, that the beds at *A*, slope under those at *B*, so we might have drawn a long series of sloping lines on to *C*, where *C* should represent the coast of the south-east of England;

[1] This contorted structure forcibly brings to mind the irregular contortions which are so generally found in foliated rocks, such as mica-schist. The same cause may well have produced the structure in both rocks.

[2] The great apparent thickness of a group of rocks in the Moffat District of South Scotland has been explained by Mr. Lapworth as produced by frequent sharp foldings, by which the beds are repeated over and over again. But we have no evidence that such an explanation can be applied to the rocks between Aberystwyth and Plynlimmon.

for this is the grand order of English rock strata, that the beds to the west slope under those to the east; the beds of the east overlying those of the west. But again, it is the primal law of stratigraphical geology that the undermost strata are the oldest; and by this law we learn that the rocks of Cambria are the lowest and oldest of rocks—they are the foundation over which England has been built up. The very lowest deposits of the Cambrian System are, however, not to be found here at Aberystwyth, though they may be reached and seen in grand development by a day's excursion to Barmouth. Our local rocks are much newer than those of Barmouth, and very probably belong to the lower part of the great Bala Group of Prof. Sedgwick. By the Geological Survey they were placed in the Lower Llandovery Group; and there are apparently conflicting facts which have yet to be put into harmony.

The suite of fossils as recorded by Salter from the Devil's Bridge has a Lower Llandovery facies, but other fossils, such as the *Dictyonema,* the Dendroid Graptolites, and the *Rastrites*, seem to be represented by similar, if not identical forms in the Llandeilo Group of the Longmynd district; the curious Polyzoon (?), the worm tracks and other markings, are near to those of the Skiddaw Group in the English Lake District, and some similar markings are also found in the Arenig country. Whilst recognizing then the present imperfection of the evidence, we may reasonably place the Aberystwyth rocks in the Lower Bala Group of Sedgwick.[1] Lithological resemblances afford us little help, but we may notice that some of the Silurian rocks of North Wales (in the Denbighshire Group) have a great likeness to those of Aberystwyth.

*Slates and Slaty Structures.*—It is proper to notice here, in further detail, those mineral masses which are so important as sources of mineral wealth to our district. These are principally the slates and metals as worked in slate quarries and metalliferous mines.

Slaty structure has been superinduced upon clayey and other rocks after their deposition by the action of lateral pressure. It is reasonable to our common sense that when a number of lenticular bodies are subjected to lateral pressure, and are allowed some slight freedom of vertical motion, they will get more or less arranged face to face, with their broad faces at right-angles to the pressure. So, too, if we wished to subject a lot of pennies to heavy lateral pressure, we should first arrange them in rows face to face, and apply the pressure along the course of the rows, for in this arrangement they are best able to sustain the pressure, and this arrangement is the most stable under the circumstances. Just so it is with the old clay deposits. We actually see under the microscope the particles of slate with

[1] N.B.—These rocks are very commonly known as *Silurian.* Through a series of errors, Sir Roderick Murchison felt compelled to absorb Sedgwick's *Cambrian* almost entirely into his *Silurian* System. But so good and true a name as the "Cambrian System," as applied to a great and natural group of rocks, honestly and successfully worked out, must not be allowed to be degraded into the appellation of a small part of that system. Such a course is not only unfair to our great leader in Cambrian geology, but is also, as I believe, a hindrance to geological science. As a name, too, the change would be unfortunate.

their long axes arranged parallel with the surface of the slate. Those great forces which puckered up the rocks into such extraordinary contortions, also caused that arrangement of the particles of rock in virtue of which the rock now splits or "cleaves" into thin slates.[1]

It is reasonable to expect that some of the transition stages between the old sea muds and the well-formed slates should in some places be found; and Aberystwyth is such a place. There is no good slate within some few miles of the town, but the clay group of rocks is represented by irregular shale, rubbly rab, soft slate, and "bastard" slate; very commonly however traces of cleavage are seen in the shale more or less clearly marked, and "rab" is in many cases produced by cleavage, often combined with joints and bedding planes.

Along the shore near Clarach well-marked slate may be seen. It is here soft and useless, but, nevertheless, it is true slate, for it may readily be seen that the lines of division are thin, and regular in direction, and that they cut across the planes of stratification at a high angle.

The constancy of the direction of the lines of splitting, as seen upon a horizontal surface (*i.e.* the *strike*) is a very well-known and characteristic feature of cleavage; in the neighbourhood of Aberystwyth this direction is about N.N.E. to S.S.W., varying only a little northwards or southwards. This being the constant direction (with rare exceptions) of the exposed edges or *strike*, the slate may stand vertical, or may slope W.N.W. or E.S.E.; most commonly the dip is about 80° W.N.W. When the planes of bedding are at all nearly in the same direction as the cleavage, the latter will accommodate itself to the lines of bedding, and run along them. Such a change in the cleavage is very prettily seen in a road-side cutting between Glandovey and Machynlleth.

In practice, however, much caution is required in registering the dips of cleavage planes, because of the phenomenon known as "surface deflection." Very generally we find on the sides of the hills that the slates have more or less toppled over in the downhill direction, so that a surface slate which should be vertical now inclines inwards and downwards towards the centre of the mountains. The numerous small openings for slate and lead, and the deep water-gulleys enable us to find the true direction.

This phenomenon is by no means confined to slates, but is also well seen in the thick beds of limestone and sandstone, in basaltic columns, etc. To explain its origin it is quite unnecessary to appeal to the force of glaciers and the grounding of icebergs, for it is obvious that, given such loosening agents as the roots of plants, and especially the alternate freezings and thawings during winter,

[1] The rock structure we have been describing above is known as cleavage, and a *slate* is the result. *Shale* is a rock which splits into thin layers along planes produced by the circumstances of its deposition. As a rule, slate is harder and more regular than shale, and especially slates often split across the planes of bedding; shale rarely does so.

gravity is constantly at work to take advantage of these shiftings, and to drag the slate or rock-bed over ; in the course of their frequent loosenings they naturally come to topple over more or less down the hill.

Large slate-workings may be visited in the neighbourhood of Corris, other good quarries are worked at Taren y Gesail and S.W. of Machynllyth (Morbern Quarry), whilst numerous small openings for local use are met with about Machynllyth, Tregaron, Strata Florida, Goginan, and, indeed, throughout the country of the Metalliferous Slate group.

*Metalliferous Veins.*—A glance at the Geological Map of Cardiganshire will show that the majority of the mineral veins run more or less parallel to one another in an E.N.E. and W.S.W. direction, roughly speaking, and we may also distinguish a separate set running more nearly from N.W. to S.E. So also, as we overlook the mines themselves from a vantage point, we may often notice that they are arranged in lines—those in the same line being probably all workings in one vein.[1] Descending into an ordinary mine, we shall find that the vein is a vertical, or nearly vertical, wall-like mass of mineral matter, sharply defined on both sides by the walls of the vein, which are often found to be polished and striated. The thickness of the "lode" or vein varies, but is very commonly about four or six feet; lateral offshoots are frequent. The vein consists of vein rubbish, spars, and ore. The "vein rubbish" is mostly hard slate-rock, like the country rock around; the spars are almost exclusively quartz, and the ores are usually lead (lead sulphide, $Pb\,S$) zinc, or black jack ($Zn\,S$) or copper (copper pyrites $Cu_2\,S$, $Fe_2\,S_3$). Silver is found in valuable quantity, but it is not distinguishable in the vein of itself, being mixed with the lead in small proportions. Practically, however, its presence is detected in the rough state, for the "silver lead" is commonly a paler and more finely crystalline ore than that in which silver is scanty.

It is probable that these veins are in the lines of old faults or rock dislocations, by which open fissures were produced, and afterwards the cavity was filled in with spars and rubbish from the sides and "country rock" around, and the ores were brought by sublimation from below.

*The Records of the Ancient Glaciers.*—We must now leave the solid geology of the country to notice what is the nature of those newer formations which are commonly classified under the heading of "surface deposits." And here the relics of the Great Glacial Period first claim our attention, since they form the oldest of this surface group, and also because they are so very conspicuous.

We need only go to Aberystwyth Castle Ground, and pick up the stones on the cliff over the railings, to find at once those peculiar

[1] It is remarkable how very frequently a lead mine is found at the head of a valley, and again they are frequent along the sides of valleys. This is probably due to the metalliferous veins, being lines of comparative weakness, so determining the lines of action of subaerial denuding forces as to produce valleys.

subangular stones with the characteristic scratches, which the geologist recognizes as the result of glacier action. Aberystwyth is built upon that deposit, and every valley in the neighbourhood has its abundant share.

The best exposure of these old glacial formations is about seven miles south of Aberystwyth, where we find a most interesting section. The cliffs here have been eaten away by the sea, and also by small streams from the land, into the most fantastic forms: deep narrow gulleys, down which we may with some difficulty climb, here and there over-arched above or again opening out into a "chine." In the cliffs lie colossal masses, large blocks, stones, and pebbles, imbedded in a matrix of coarse sandy clay, irregularly mixed together, without any such arrangement as invariably obtains in ordinary water-formed rocks. Nearly every stone has its face or all its faces scratched and smoothed.

All the stones are such as may have come from within a few miles of where they now lie, grit, greywacke, slate, shale, and mudstone, with a few quartz boulders, forming the great porportion. They were brought down and deposited here by local glaciers—rivers of ice, which had their birthplace in the higher hills inland, and stretched out their long ice-arms and ice-sheets in all directions towards the lower ground.

Many a Welsh valley has a most typical glacial aspect—a broad, open, half-amphitheatre-like head, which formed the "gathering ground" of the glacier where the snows principally collected, and below an open valley U shaped in section, its sides regular, and every feature rounded. For in this part of its course below the head the snows had become changed into hard blue ice moving slowly and steadily down, either to its end where it was melted in the lower grounds, or to reach the sea where it was broken up and carried away in the form of icebergs. Such ice-streams, grinding their way down the valleys, would allow of no asperities, no sharp features, but all was smoothed and rounded.

Wherever a side stream, now entering the old glacier-rounded valley, has more recently cut back for itself a deep bed, its angular valley with rough irregular sides form striking contrasts to the glacier-carved surfaces. This is very well seen from the Devil's Bridge road, looking towards Pen-y-ffrwd, where a small stream leaps down the steep valley side facing you; and every one who walks much into the country around may find every day fresh examples of the two contrasting types of valley.

Yet more exact tracks of the local glaciers remain in the rounded rock bosses known as "roches moutonnées," and the polishings, scratchings, and groovings still left upon the solid rock. Such traces of glaciers are well seen in many places around Aberystwyth, such as the valley above Eglws Fach, the Ystwyth valley on the Lisburne Mine private road, in the Rheidol valley at Ty Llwydd, by the road-side between Pont Erwyd and Steddfa Gurig, in the mine works, on the side of Plynlimmon above Steddfa Gurig, and in the Domen valley. In all these places polished and striated rock-surfaces are seen as well marked as in an Alpine valley where the glacier has but lately retired. These are the tool-markings of our ancient glaciers and they are marvellously well preserved.

But these Welsh glaciers were not confined within the limits of the present valleys; they often overspread such boundaries to open out upon the lower hills, and, it may have been, there to form a continuous sheet many miles in breadth. The hills around Aberystwyth are from about 300 to 700 feet high, and over all these the glacial deposits of stony clay, etc., may be seen with all their usual characters, and with numerous large transported blocks left there as the glacier retired. On the higher ground to the east of Llanfihangel crowds of these blocks cover the ground, and above Cwm Symlog large masses are seen stranded at above 1000 feet.[1] These blocks too are often strewn over the sides of valleys, where they were left at the edges of the glaciers as they dwindled away.

It is remarkable that those puzzling mounds of false-bedded sand and gravel, known as Ösar in Scandinavia, were distinguished by the ancient Celtic peoples both of Scotland and Ireland. By the former they were called Kames; by the latter Eskers.

Nor were the people of that other great branch of the Celtic race, the Cymri, wanting in the same extraordinary discrimination in detecting these ridges; for here in Wales the name *Esgair* or *Escair* is by no means uncommon,—evidently the same word as the Irish Esker. For example, we may point out the name "Esgair Annos," which designates a characteristic Esker east of Rhyader.[2]

Near Llanrwsted Road, Aberystwyth, an enormous Esker is seen stretching its broad back more than 100 feet high across the valley of the Ystwith, like a terminal moraine. Through it the river has cut its present channel down to and into the solid Cambrian rock.

Two railway cuttings afford us excellent views of the structure of this Esker. At once we are struck with the great irregularity and steep false-bedding of the deposits, *i.e.* the layers of material were not thrown down horizontally; and, looking closer at the anatomy of the section, we find combined evidences of both water and ice-action. There is the stratification of water; the false-bedding of rapid currents and eddies; and there are the subangular and well-scratched stones, telling us of the work of ice. Many of the pebbles are of the ice-formed types, but some are perfectly rounded.

We have no evidence of any modern encroachment of the sea up to where this giant Esker lies. I look to the combined actions of ice and water, and perhaps snow, to explain its formation. It is contrary to experience that the sea should pile up a huge bank of materials so little water-worn, with so many of the stones still

[1] All these blocks are from the local grit and hard shale-beds, or more rarely a conglomerate from Plynlimmon. In the Ystwyth Valley, and towards Machynlleth, a pale-coloured hard granular and felsitic-looking rock occurs, whose origin is not yet known to me.

[2] It seems probable, from subsequent observations, that this local name *Esgair*, may sometimes have been applied to mounds of a different origin and structure from that of *Eskers* properly so called.

retaining their glacial striæ and their subangular contours, as in this Esker.

As the glaciers retired, the melting of the ice and snows gave rise to exaggerated river action, so that the valleys were swept by rapid water-currents, often carrying loads of stones stolen from the glaciers and their moraines. These materials, being rounded as they rolled along the bed of the stream, were roughly arranged and deposited above the proper glacial formations, over which we now usually find them. Such formations are well seen in the cliffs some few miles south of Aberystwyth, and at Clarach; also the coarse pebbly deposits at Tregaron, through which the river has cut, and perhaps some others of our river deposits belong to this stage.

We have not yet found in our neighbourhood any evidence of such a succession of glacial periods, interglacial periods and great quaternary submergences as are described in other areas. All the phenomena we observe here may well have been produced during a late period by local glaciers.

We have as yet no means of telling the absolute date in years at which our islands were subjected to these glacial conditions, but we have a very marked record of that date, if we could but read it, in the gorges which streams and waterfalls have cut since the glaciers disappeared. For we have seen that the glaciers left their banks all smoothed and rounded, and it is most conspicuous how far the more rugged and angular beds which have been since produced by the streams of water extend back beyond them. Here then is our record, and when we can determine the rate at which the streams cut back their beds, then we shall easily calculate how long it is since glacial conditions existed here.

*The Latest Geological Phenomena.*—Since that time comparatively little geological deposit has been added to the country. The rivers have formed flat lands of pebble beds, loam, and sand, and have again cut down deeply through them, as is well seen in the Rheidol Valley near Ty Llwydd: but these deposits contain no fossils except here and there a piece of wood. Their pebbles are to a great extent derived from the denudation of the glacial deposits,—most barren records.

In many places however where quiet or stagnant water was kept in, extensive beds of clay and peat have been formed, the peat uppermost. The Tregaron Valley is a good example of this, for here a very pure and homogeneous soft blue clay is found together with the overlying peat well developed. Very generally such deposits yield many interesting fossils,—shells in the clay and bones of mammals in the peat, but that is not the case here. I have only met with two antlers of the Red Deer (*Cervus elaphus*) in the clay near Borth,[1] and have not found any animal-remains in the peat. This is the more strange, because we know that many animals have lived in this region during the more recent periods, whose remains one would expect to find; such, for instance, as the Beaver, whose

[1] One of these was presented to the University College Museum by Mrs. Davies of Antaran.

last British stronghold was in the Teifi; the Bear, whose former presence is proved by such names as Pwl cenawen[1] (the cubs' pool); and the Otter, which is still hunted in the streams. Trees are however often found well preserved in the peat; their roots and trunks may always be seen where turf-cutting is going on and sometimes fine trees are found. In the neighbourhood of Tregaron the wood is still used by the carpenters, and portions of trunks are very commonly made into rollers for the fields.

The best exposure of these prostrate trees is the submerged forest at Borth. Here at low water hundreds of 'stools' with their roots still fixed in the old soil are seen; while prostrate trunks and branches are abundantly scattered around. The Oak, Pine, and Beech are most numerous. The soil upon which they grew was very peaty, and was made up to a great extent of reeds, flags, and other vegetable matter matted together. The decomposition of the tissues of these plants gives rise to gases which are now being evolved, and sulphuretted hydrogen especially may be recognized by its fetid odour when the peat is disturbed. Such an old land surface is found throughout Cardigan Bay, extending from below low-water mark to a distance of several miles up the valleys. At Clarach it is occasionally laid bare, and it is nearly always exposed at Tan-y-Bwlch, south of Aberystwyth.

Beneath the submerged forest at Borth there is a blue clay containing marine shells (*Scrobicularia piperata* and *Rissoa pallida*), in great profusion.

In these various deposits on the Borth shore we have the evidence of three changes in the relative level of land and sea. First the old Cambrian rocks were submerged to allow of the deposition of the Scrobicularia clay; then came an upheaval carrying the latter deposit above high-water mark at least, when the peaty formation was produced in the swampy flat; and, later on, the beech and pine forests flourished. But again came a depression, which submerged the forest and killed the trees, many of which probably stood long, as bare, leafless skeletons, to be blown down and strewn irregularly along the shore and over the sea-bottom. Only the stools now remain erect; every tree is prostrate.

*Physical Geography.*—The connexion between the physical geography of a country and its geology must everywhere be most intimate; and their correlations are generally as easily explained as they are evident. Rocks have their characteristic surface features as well as their characteristic fossils. The rich low country with its many little hills of Tertiary counties, and the grand alternating series of limestone ridges and fertile plains of the Secondary districts of England, are equally foreign to our neighbourhood. In a country composed of such enduring rocks as prevail in Mid Wales, we are sure to find a more grand and rugged type of scenery, which is only repeated in those areas whose geological structure is similar to it, such as the Lake District of England and parts of Scotland.

[1] The name of a farm-house near Penllwyn.

Amongst these, too, Mid Wales has its own physical characteristics, which distinguish it from other Cambrian districts. We miss especially the high precipitous escarpments with their scree slopes below, and the sharp peaks of the more northern Cambrian areas, and the scenery is altogether less rugged than those. This is sufficiently explained by the homogeneous character of the Mid Wales rocks, the rare occurrence of thick deposits of hard grit and quartzite, and the absence of igneous rocks. It is not till we reach Plynlimmon, and again go still further east to the neighbourhood of Rhyader, that we find more massive grit-beds and conglomerates, and here the bolder features of steep rugged hill-sides and precipitous escarpments are found.

We have already, when dealing with the Glacial period, referred to that moulding of the surface features by the action of ice which has so profoundly modified the character of our scenery, but we may here dwell longer upon those more angular valleys which have been produced by the action of streams since the ice disappeared. Such valleys are, as a rule, best developed in the neighbourhood of waterfalls, for there the cutting power of water is at its maximum. At the Devil's Bridge, Pont Erwyd, and below Llyn Rhyddnant, especially, deep chasms have been cut out by the long-continued action of the water as it rushes down and hurls the stones, large and small, like cannon-balls and gun-shot against the sides and bottom of its bed. The characteristic water-cut sides are well seen in the "Devil's Punch Bowl" of the Devil's Bridge, and the same appearances should be noticed all up the sides of the chasm. They are well seen lower down on the left bank of the waterfall above the iron foot-bridge; thus presenting to us the most convincing proof that the gorge has been cut out by the water itself, and is not a gaping fissure produced by violent earth movements.

The Caradoc waterfall, between Traws Coed and Strata Florida, is remarkable in that the slope of the fall corresponds with a sudden fold in the rock-beds themselves,—a coincidence which is most unusual.

Those cylindrical holes known as "Pot-holes" are well seen along the Rheidol in many places, as at the Parson's Bridge, Devil's Bridge, and higher up around Pont Erwyd. These are good illustrations of that mode of working by water with the aid of hard stones which we have already noticed. At the bottom of the Pot-holes some stones are sure to be found, and it will at once be evident that as the current of water flows over the hole, a spiral motion is set up in the water of the Pot-hole, so that the stones are carried round and round the bottom of the hole, always grinding their way deeper and deeper down. It is interesting to notice that in this way water may carve out great hollows below its level of outflow. The holes vary much in size; some are no bigger than beer tumblers, in others one might hide oneself.

*The Plane of Marine Denudation.*—Whoever has gone to the top of the higher mountains of England, Scotland, Ireland, Germany, Switzerland, etc., must have noticed that the great spread of country around him looks much more regular than he would have expected from his previous knowledge of the lower grounds. He may have considered the whole country mountainous, and quite irregular; but now, from his elevated position, he is surprised to find how very level and regular it looks. Now he sees all around a great plain, in which the valleys appear as huge furrows ploughed out. The same feature, viz. the regular height of the summits of most of the hills, and their comparative evenness, may also sometimes be observed as you look at a mountain system from a distance, when the tops of a number of mountains are seen to be so many points in the same straight line. Such a plane is known as a "Plane of Marine Denudation"; and it may be well seen from the top of Aran Mowddwy, Cader Idris, Snowdon, Plynlimmon, or nearer home from the top of the hill above Cefn Hendre, Aberystwyth. The height of this plane in Cardiganshire is from 500 feet to about 750 feet, gradually sloping upwards to the Plynlimmon mountains.

This plane of marine denudation tells us of a period, far removed from our age, where the sea gradually cut inland its level shores and sea-bottom, levelling all down and leaving only the higher mountains, as Plynlimmon, Cader Idris, etc., as isolated islands. Just in the same way the sea is now cutting down another plane; it is slowly eating away Constitution Hill, and every other hill along the coast, and reducing all to one level—a modern plane of marine denudation.

*Lakes and their Modes of Origin.*—Another feature which Mid Wales has in common with most mountain districts is its numerous lakes. A number of these may be visited from Aberystwyth, though most of them are not easily accessible, for they are generally situated, not in the valleys, but upon the summit plains of the hills. They are depressions in the great plane of marine denudation. Such are Llyn Eiddwyn, L. Gynon L. Fyrddyn, L. Gron, L. Egnant, L. y Gorlan, L. Hir, and Llyn Teifi, etc. The five latter are the best known under the name of Teifi Pools, and they will serve well as illustrative examples of the most common type of lake in Mid Wales.

Far up in the hills we find these irregular bodies of water with their walls all formed of solid rock. They generally run more or less along the strike of the rock-bed, their sides are not lofty (rarely so much as 100 ft.), and in many cases at least their depth is not great.[1] [2]

There are three principal ways by which lakes may be formed, (1) by the action of ice scooping out a hollow in the solid rock; (2) the formation of a dam across a valley, as by the moraine matter piled up at the end of a glacier; and (3) by earth movements, especially *depressions*.

The Teifi Pools, together with the great majority of our Mid Wales lakes, belong to the third class. Here we have not

> "A lofty precipice in front,
> A silent tarn below,"

[1] The depths of many of the lakes are not yet known to me.

[2] The visitor must take care to distinguish the natural lakes from the artificial reservoirs of water made by the lead-workers to serve for a steady supply of water to their water-wheels.

which is so characteristic of class (1), there is no gathering ground here for the snows to collect in and form a glacier. Again, the continuity of the solid rock all around decides at once against the theory of a moraine dam. No—in Mid Wales we have a crowd of lakes formed by vertical depressions of the solid rock. Very generally the rock-beds are seen sloping down towards the lake on two or three sides, and on one side there may in some cases have been a break in the continuity of the rock—a slowly-formed local fault.

We have, however, a good example of an ice-formed lake in Llyn Llygad-y-Rheidol under Plynlimmon. The position of this lake is highly favourable for the denuding action of ice. Snows gathered abundantly upon the heights above, and a glacier certainly did descend into the valley in which the lake now lies; it is then highly probable that the ice here scooped out a hollow. This may well be, but we have besides an obvious cause for the existence of a lake here in the bank of glacial moraine which is now seen running across the valley at the foot of the lake, and through which the stream has cut for about 25 feet. Llyn Llygad-y-Rheidol is then a good example of our class (2), but it is not unlikely that the scooping power of ice (class 1) may have deepened its rock-bed.

*The Beach Pebbles.*—We must add a few words about the stones of the Aberystwyth beach. Most of these are, of course, rounded pieces of the grit, greywacke, and shale of the cliffs around, but these are scarcely noticeable to the searcher among the more conspicuous hard pebbles which are so numerous and so various. In a few minutes we may pick up quartzites, conglomerates of various colours, felsites, mostly quartz felsite, several varieties of granite, hornblendic granite, syenite, many species of greenstones, and numerous metamorphic rocks. We may also find a chalk flint or perhaps a more valuable "pebble" in the technical sense of that word as used by the lapidaries. The homes of many of these pebbles are not yet known to me; the flints and agates might have come from the chalk and basalt of co. Antrim in the N.E. of Ireland, and other pebbles might have been picked up along the Carnarvon peninsula and carried southwards by currents, but I have not yet been able to identify any such with certainty. On the other hand, it may be that in the Glacial period, while the snow and ice covered the land, icebergs freighted with rocks from other lands floated down the Irish Sea, and dropped their burdens of foreign stones down to the sea-bottom so as to form a Boulder-clay. Such a deposit, now being denuded by marine currents, might well yield us such a variety of pebbles as we find upon the beach. But we have not yet the materials ready to decide which of these theories is the true account.

Specimens of the rocks, fossils, etc., above mentioned, may be seen arranged in the Museum of the University College of Wales.

Note.—It will be observed that these Notes on the Geology of Aberystwyth (originally intended for publication in a local guide-book) are very imperfect. To a great extent this is due to the scanty work that has yet been done in our neighbourhood, and we hope that very soon many of the points now doubtful—such, for instance, as the exact age of the Aberystwyth group and the origin of the beach pebbles—will be clearly made out. As the work progresses, I hope to publish elsewhere more detailed accounts, and to describe the fossils. But the imperfection is the greater on account of the necessity which obliges me to write these pages when absent from Wales and without materials at hand to help me.

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## III.—Notes respecting Chloritic Marl and Upper Greensand.

By C. J. A. Meÿer, F.G.S.

HAVING paid but little attention to geological literature during the last two years, it was not until September, 1878, that I became aware of Mr. A. J. Jukes Browne's article in the Geological Magazine of August, 1877.[1] In this article, amongst other matters, the author criticises very fairly the classification of the Upper Greensand and "Chloritic Marl," so-called, as set forth in my paper on the Cretaceous Rocks of Beer Head.[2] In justice to certain questions involved, I find myself compelled to reply to this criticism, and to say a few words besides respecting the Chloritic Marl and Upper Greensand.

In my description of the Cretaceous Rocks of Beer Head—after showing the great difference between the faunas of the highest and lowest beds of what had been always previously classified as Upper Greensand, and after proving that the one represented a Blackdown, the other a Warminster fauna—I suggested that beds 10 to 12 of my section therein given, on account of their special fauna, should be separated from the Upper Greensand under the distinctive title of *Warminster Beds.* I further pointed out that beds 10 to 12 represented, both in fauna and position, the so-called "Chloritic Marl" of the Isle of Wight.

In suggesting the term *Warminster Beds* for my beds 10 to 12, I ought at the time, indeed, to have explained that by such term I meant that portion only of the Warminster strata from which, at Chute Farm, near Warminster, so rich a fauna has been collected, and which fauna has been always spoken of, erroneously as I think, as coming from the *Upper Greensand* of Warminster. For the actual "Upper Greensand" of Warminster, as every one knows, is of considerable thickness. It consists in the lower part of sandy marl, resting at Crockerton on *Gault,* and passing upwards, as in the coast sections, into sands with Chert;—the usual "Malm Series" and "Chert Series," in fact, of the Upper Greensand.

But none of these beds contain the noted "Warminster fossils." These fossils are, and always have been, collected from the surface of the field in which they once abounded, the rock which yields, or yielded, them being unexposed. Portions of the *matrix* may be seen, however, both outside and inside many of these fossils, and such matrix has the appearance of Chloritic Marl, although the cement is now siliceous instead of calcareous.

The "Chute Farm" fauna is then the Warminster fauna, as generally known. It is also the fauna, in great measure, of my beds

[1] Geol. Mag. Dec. II. Vol. IV. p. 350.
[2] Quart. Journ. Geol. Soc. vol. xxx. p. 369.

10 to 12 of Beer Head, and of the so-called "Chloritic Marl" of the Isle of Wight, and of Chardstock. 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"? [1]

Dr. C. Barrois, Mr. A. J. Jukes Browne,[2] and probably many other geologists, consider that I was wrong. Because, say they, the fauna of beds 10 to 12 is found also in the Upper Greensand. But where? Not at Beer Head. And, with the exception of *Pecten asper* and one or two other wide-ranging fossils, not at Warminster. Nor yet, in reality, in the Isle of Wight. Barrois, quoting from older lists, gives indeed a number of species as coming from the Chert Beds at Warminster,[3] and others as from the Upper Greensand of the Isle of Wight.[4] The greater part of these however came, probably, on his own showing, from the base of the "Chloritic Marl" of Ibbetson. To prove this I also, following Mr. Jukes Browne's example, must say a word or two respecting that much-abused term, "Chloritic Marl."

Now Mr. Jukes Browne,[5] in his otherwise careful and valuable *résumé* on the origin and application of the term "Chloritic Marl," has failed, apparently, to notice one point of considerable importance in respect to it, and one from which in fact has arisen very much of the difference in thought and practice regarding the application of the term. And it is this:—That under the term "Chloritic Marl," Captain Ibbetson (in 1849) would seem to have included two beds of very similar composition; both loaded with green grains, both phosphatic. Beds which although in actual contact were certainly in age widely separated. Captain Ibbetson's "Chloritic Marl" embraced in fact the (local) top of the Upper Greensand, and the (local) bottom of the Chalk Marl of the Isle of Wight.

For "The Chloritic Marl," says Captain Ibbetson,[6] "divides the Chalk Marl from the Upper Greensand. It is a grey marl full of green grains of a silicate of iron and sand, very fossiliferous. The upper part in places exhibits a conglomerate of pebbles and small boulders, and in it the fossils are chiefly broken as if rolled on a beach."

Now, all who have examined the junction-beds of the Upper Greensand and Chalk Marl near St. Catharine's Down, in the Isle of Wight, will see the significance of the above description. The "conglomerate of pebbles and small boulders" occurs on the actual line of division of two faunas. The lower of which includes *Pecten asper*, *Terebratella pectita*, *Catopygus columbarius*, *Galerites castanea* and various other Echinoderms; the upper, *Ammonites*, *Scaphites*, *Turrilites*, etc., mostly phosphatic. It might, perhaps, be objected that

[1] Quart. Journ. Geol. Soc. vol. xxx. p. 371.
[2] Geol. Mag. Dec. II. Vol. IV. p. 358.
[3] Recherches sur la Terrain Crétacé sup. de l'Angleterre, par Ch. Barrois, D.Sc., Lille, 1876, p. 58.
[4] L'Age des Couches de Blackdown, par. Ch. Barrois, D.Sc., An. Soc. Geol. du Nord, tom. iii. p 4.
[5] Geol. Mag. Dec. II. Vol. IV. p. 355.
[6] Notes, etc., on the Strata of the Isle of Wight, London, 1849.

the term "Chloritic Marl" has been always subsequently applied to the upper of these two beds—the "Scaphites-bed" or actual base-bed of the Chalk Marl. Such, however, is not the case. In Mem. Geol. Survey, Dec. iii. page 4, Professor Forbes, referring to Chloritic Marl, says:—"It is a remarkable stratum abounding in peculiar fossils, and containing numerous Echinoderms. I have examined it and found the small variety of *Galerites castanea* plentifully near the village of Chaldon, in Dorsetshire." "Both larger and smaller varieties occur near Warminster." Now the small variety of *Galerites castanea*, in the Isle of Wight, belongs especially to the lower half of the Chloritic Marl of Ibbetson.

It appears, therefore, that the term "Chloritic Marl" as first applied embraced two sets of strata with, in time at least, a gap between them.

In the light of recent researches this fact has become more evident than it could possibly have been in former times. One knows now that the Cretaceous rocks do not exhibit in any one locality a perfect series. Here and there some bed is wanting—rarely indeed without some sign or indication of the fact. Pebble-beds, grit-beds, layers of phosphatic nodules, lines of erosion, and sudden changes of fauna, all point usually to missing strata. And in no part of the Cretaceous rocks is this, perhaps, more frequently evident than between the Upper Gault and the Chalk with *Inoceramus labiatus*. To illustrate this one need but follow the, already, partly recognized life-zones of the intermediate strata. For, thanks to Hébert, Barrois, and other diligent observers, it is now well-nigh established that beneath the Chalk with *Inoceramus labiatus* one finds, or ought to find, the following life-zones:—

*g.* Zone of *Belemnites plenus*.
*f.* „ *Holaster subglobosus*.
*e.* „ *Scaphites æqualis* = The zone of *Ammonites laticlavius*, of Barrois.
*d.* „ *Holaster nodulosus* (of Hébert).
*c.* „ *Trigonia sulcataria*.
*b.* „ *Ostrea vesiculosa*, and *Janira quadricostata*
} = The zone of *Pecten asper*, of Barrois.
*a.* „ *Exogyra conica* and *Cardiaster fossarius* = The zone of *Ammonites inflatus* (in part), of Barrois.

But, at Folkestone, zones *a. b. c. d.* are missing. At Cambridge *a. b. c. d.* and *e.* are missing. While near Beer Head *g.* in places rests on *d.* And, probably, because the bases of zones *d. e. f. g.* contain green grains and *remanie* phosphatic fossils in some localities, the term "Chloritic Marl" has been at various times applied to each and all. Nor is this surprising. For one finds that in France and Belgium the, to some extent, equivalent terms "Tourtia" and "Marne Glauconieuse" have been also not infrequently applied to beds of various ages.

That the term "Chloritic Marl" is then, and has always been, a bad one, is clear enough. Yet this in no way affects the correctness of my reference of beds 10 to 12 of the Devon sections to Chloritic Marl.[1] These beds embrace the Chloritic Marl of the Isle of Wight and more besides. The *phosphatic fossils* in bed 13 of Beer Head

[1] Quart. Journ. Geol. Soc. vol. xxx. p. 385.

(referred by Barrois to Chloritic Marl)[1] are entirely *remanie* of older beds. Bed 13 itself is of the zone of *Belemnites plenus*, and is followed immediately by the zone of *Inoceramus labiatus*. Recent investigation has proved to me that I was wrong therefore in giving to *Holaster subglobosus* so wide a range in my tables of fossils.[2] In the vicinity of Beer Head *Holaster subglobosus* occurs in places in bed 12. Rarely between beds 12 and 13.

Or, in the Beer Head and Branscombe cliffs :—

Beds 16, 15, 14 = The zone of *Inoceramus labiatus*.
Bed 13 = The zone of *Belemnites plenus*.
Beds 12, 11, 10 = Condensed life-zones apparently of:
*Holaster subglobosus.*
*Scaphites æqualis.*
*Holaster nodulosus.*
*Trigonia sulcataria.*

Now the Upper Greensand (typical) of the Isle of Wight—both Chert Series and Malm Series—is fully represented in the Devon cliffs by my beds 6, 5, 4, 3. Beds 8 and 9 not being present in the Isle of Wight. To separate beds 10, 11, 12 from the Upper Greensand of the Devon cliffs does not, therefore, in any way diminish the original range of the Upper Greensand, as Mr. Jukes Browne apparently supposes.[3]

Moreover, my beds 8 and 9 with *Orbitolites concava*, and bed 10 with *Trigonia sulcataria*, *Codiopsis doma*, etc., represent respectively the "*Craie de Rouen*" and "*Gres du Maine*," in part, of Prof. Hébert.[4] And these beds, though widely developed in France, seem absolutely unrepresented in the Isle of Wight. And, inasmuch as the *position of* beds 8 and 9 is actually between the Chert Beds of the Isle of Wight and the base of the Chloritic Marl of Ibbetson, there is in this again a further reason for distinguishing my Warminster beds (10, 11, 12) from the Malm Series and Chert Series of the Upper Greensand. For these and other reasons I cannot agree with Dr. C. Barrois and Mr. A. J. Jukes Browne in classifying beds 10, 11, 12 with the Upper Greensand.

Neither should English geologists too hastily agree with Dr. Barrois' definition of the Upper Greensand as found in England.[5] The fauna of our Upper Greensand is a poor one undoubtedly. And it is true enough (as Dr. Barrois says) that the fauna of the Malm Series of the Upper Greensand approaches to that of Blackdown, and the fauna of the Chert Series to that of Warminster. But it is not, therefore, necessary to divide the Upper Greensand. The English Upper Greensand fauna has never been worked out carefully. When this has been done it will be found probably to approach more nearly, *as a whole*, to that of the "Meule de Bracquegnies" than *separately* to the faunas of Blackdown and

[1] Recherches sur le Ter. Crét. de l'Angleterre, Lille, 1876, page 71.
[2] Quart. Journ. Geol. Soc. vol. xxx. p. 386.
[3] GEOL. MAG. Dec. II. Vol. IV. p. 357.
[4] Bull. Soc. Geol. de France, 2$^{e}$ ser. vol. xx.
[5] L'Age des Couches de Blackdown, par Ch. Barrois, An. Soc. Geol. du Nord, tom. iii. p. 1.

Warminster. For the fossils of the "Meule de Bracquegnies," so many of which have been referred by MM. Cornet and Briart to Blackdown species,[1] appear to me to form rather the passage fauna between the (in England) totally distinct faunas of Blackdown and Warminster.

While thus maintaining the correctness of correlating beds 10 to 12 *and the Warminster beds of Chute Farm* with the Chloritic Marl of Ibbetson, and of distinguishing all alike from the Upper Greensand, I ought at the same time to admit that such an arrangement still leaves much to be more fully determined. Beds 10 to 12 and the Warminster beds will still, to some extent, represent an unknown quantity, inasmuch as they themselves include beds of various ages, *partly remanie*, and which are probably elsewhere very differently represented. Judged by their fauna they include certainly two, if not three, divisions of the French and Belgian "Tourtias," as defined by MM. Dumont, Cornet and Briart, Hébert, Gosselet, Barrois,—and in part also the "Grünsand (Tourtia) von Essen." Fragmentary beds all of them, existing often only as outliers, and the exact correlation of which even Barrois[2] finds yet difficult to determine.

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## IV.—On the Possibility of Changes in the Latitudes of Places on the Earth's Surface; being a Reply to Mr. Hill's Letter.

By O. Fisher, Clk., M.A., F.G.S.

I AM grateful to Mr. Hill for noticing my former paper "On Possible Changes of Latitude on the Earth's Surface" in his letter, October, 1878, p. 479. I wish, however, that he had gone into the subject more in detail; in which case I, and perhaps others, would have felt more satisfied with his reply. He epitomizes my appeal to physicists by making me ask, "Assuming that a thin crust surrounds a fluid substratum, could then a deformation shift the crust over the nucleus?" And he replies that, Mr. G. Darwin having proved that the earth is "enormously stiff," the discussion would be fruitless. But in this statement of my question and reply to it, he has omitted what seems to me the important proviso, based on Hopkins' reasoning about the mode of cooling, that this fluid substratum is shallow, and encloses a *rigid* nucleus; and given no reply to my inquiry whether such a supposition might not afford the required rigidity.

Again, referring to the recent disproof of Hopkins' demonstration of rigidity drawn from the amount of precession, Mr. Hill argues that, since the fluid nucleus being spheroidal and rotating would resist the tilting force which produces precession, and the shell would not slide freely, "would it not also resist the tilting tendency resulting from a deformation?" I am not quite certain that I understand this. If Mr. Hill means that the rotation would compel the fluid substratum to retain its spheroidal form, so that a *rigid* crust

[1] Briart et Cornet, Mémoires de l'Académie R. de Belgique, tom. xxxiv.

[2] Mem. sur le Terrain Crétacé des Ardennes, etc., par Chas. Barrois, D.Sc., Lille, 1878, p. 346.

could not slide over it, I grant that there would be truth in the objection. But if the crust be considered flexible, as practically it must be if of small thickness and liable to corrugation, then I do not see why the rotation of the fluid should have the effect of preventing the crust slipping over the nucleus, and adapting itself to such a position of equilibrium, as any irregularities of thickness resulting from corrugation might render necessary under the action of the centrifugal force and gravitation.

The final query put by Mr. Hill is this—"Will a change in latitudes give the best explanation of the phenomena?" To this I reply, that we have *four* chief classes of facts to account for:

1. The almost ubiquitous presence, either in present or past times, of volcanic action; apparently showing that wherever the earth's surface is pierced to a sufficient depth, a molten stratum is tapped.
2. The capacity for slipping towards certain lines which the crust possesses, as proved by the lateral compression of the strata along the flanks of mountain chains.
3. The amount of horizontal compression of the superficial strata being greater than the cooling of a solid earth can account for.
4. Changes of climate—notably the existence of a warm climate in former times near the North Pole.

These are the phenomena, and it appears to me that these four classes of facts point convergently towards the doctrine of a fluid substratum. It is quite true that the question which I put to physicists and now repeat was *whether a fluid substratum over a rigid nucleus would not be compatible with mechanical considerations, and whether under those circumstances changes in latitude would not result from unequal thickening of the crust?* And I suggested that the present distribution of the continents gives support to that idea. But I was not seeking *primarily* to account for changes of climate in that manner. 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.

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## V.—On the Occurrence of *Terebratula Morieri* in England.

By John Francis Walker, M.A., F.G.S., etc.

A VALUABLE paper by T. Davidson, Esq., F.R.S., appeared in the Proceedings of the Dorset Natural History and Antiquarian Field Club for 1877, "On the species of Brachiopoda that occur in the Inferior Oolite at Bradford Abbas and its vicinity." Since then, during a recent visit to this locality, I have added a few species to this list, including two which have not been discovered in England before. I propose to give a short account of these species, and also a table showing the relative distribution of the Brachiopoda in the Inferior Oolite and Fuller's Earth deposits at Cheltenham and France, compared with this district.

The most important discovery is that of the well-marked species *Terebratula Morièri*, which has hitherto only been found in France. It was first described and figured by Mr. Davidson in the Annals of Natural History for 1852, vol. ix. (second series) p. 256, pl. xiv. fig. 3 and *a*, *b*,—the MS. name of *Terebratula Morièri* having been given to it by Deslongchamps after its discoverer M. Morière. It was afterwards described and figured by E. Deslongchamps in 1857, "Catalogue descriptif des Brachiopodes du système Oolitique Inférieur du Calvados," p. 37, pl. iv. fig. 6, *a*, *b*; and in 1877, in the Paléontologie Française Terrain Jurassique, Brachiopodes, p. 244, pl. lxv. figs. 1–8. It is a very rare species, having been found in France in only one locality, Ste. Honorine des Perthes (Calvados), in the white Oolite of Port-en-Bessin, which contains *Terebratula Phillipsii*, Morris, and *Rhynchonella plicatella*, Sow.; these species occur with it in England.

There appears to have been some doubt whether in France this species had been found in position, or in a loose block which might have fallen from the Great Oolite above. M. Deslongchamps regarded it as an Inferior Oolite fossil, but the finding of this species settles the question with regard to its age, as no Great Oolite occurs in the quarry from which I obtained this specimen.

Whilst examining the well-known quarry at Bradford Abbas, on the farm of Prof. Buckman, I picked up this specimen from the horizon of *Rhynchonella parvula*, E. Desl., but did not recognize it until I commenced to clean it; it corresponds in all respects with the figured specimens, showing the deep sinus in both valves and the peculiar concentric projecting imbricated ridges which well distinguish this species. It belongs to a small group, of which it is the earliest representative, followed, in the Fuller's Earth rock, by *Terebratula reticulata* and the closely-allied or identical species *Terebratula hybrida*, and in the Great Oolite by *Terebratula coarctata*. The specimen is about the size of figure 7 in pl. 65, Pal. Franç. Brachiopodes Jurassique. It is well preserved, both valves being perfect. I also obtained from the quarries at Half Way House a specimen of *Rhynchonella subdecorata*, and one or two specimens of *Rhyn. ringens* unusually large for English specimens. Also three specimens of a *Waldheimia* which appears to be *Waldheimia subbucculenta*, Chap. et Dew., and probably the same as the species figured, but not named, by Mr. Davidson in his paper on the Dorset Brachiopoda, pl. iii. figs. 14–15. *Waldheimia subbucculenta* is stated to occur in France in the lower part of the Fuller's Earth, but probably what in England would be called the upper part of the Inferior Oolite. It is a species which is closely allied to *W. Waltoni*, Dav., and somewhat resembles *W. indentata* and *W. perforata* of the Lias; *W. humeralis* of the Kimmeridge; and *pseudojurensis* of the Neocomian. It is a long, narrow, flat shell, tapering towards the beak and front margin, foramen small, beak ridges well defined, and a dark line on the smaller valve indicates the presence of a septum, showing that the loop was long. It will be figured with the other species in the appendix to Mr. Davidson's supplement to his great work on Jurassic Brachiopoda.

LIST OF BRACHIOPODA FOUND IN THE INFERIOR OOLITE AND FULLER'S EARTH.

| *Explanations.*—r = rare, s = scarce, c = common, * other localities only. | Somerset and Dorset. | | Chelten-ham. | | France. | |
|---|---|---|---|---|---|---|
| | I. O. | F. E. | I. O. | F. E. | I. O. | F. E. |
| **Lingula Beanii*, Phillips (Yorkshire) | ..... | ..... | ..... | ..... | ? | ..... |
| **Discina reflexa*, Sow. (Yorkshire) | ..... | ..... | ..... | ..... | ..... | ..... |
| *Dundriensis*, Dav. (Dundry) | r | ..... | ..... | ..... | ..... | ..... |
| *Etheridgii*, Dav. (Nailsworth) | ..... | ..... | r | ..... | ..... | ..... |
| *Crania Saundersi*, Moore (Dundry) | r | ..... | ? | ..... | ..... | ..... |
| *canalis*, Moore (Dundry) | r | ..... | ..... | ..... | ..... | ..... |
| *Spiriferina ? Oolitica*, Moore (Dundry) | r | ..... | ..... | ..... | ..... | ..... |
| *minuta*, Moore (Dundry) | c | ..... | ..... | ..... | ..... | ..... |
| *Thecidium Bouchardi*, Dav. (Dundry) | r | ..... | ..... | ..... | ..... | ..... |
| *Dickensoni*, Moore (Dinnington) | r | ..... | ..... | ..... | ..... | ..... |
| *triangulare*, D'Orb. | c | c | r | ..... | ? | ..... |
| *duplicatum*, Moore (Dundry) | r | ..... | ..... | ..... | ..... | ..... |
| *serratum*, Moore (Dundry) | r | ..... | ..... | ..... | ..... | ..... |
| *Forbesii*, Moore (Dundry) | r | ..... | ..... | ..... | ..... | ..... |
| *septatum*, Moore (Dundry) | r | ..... | ..... | ..... | ..... | ..... |
| *granulosum*, Moore (Dundry) | r | ..... | ..... | ..... | ..... | ..... |
| *Argiope ? Oolitica*, Dav. (Dundry) | r | ..... | ..... | ..... | ..... | ..... |
| *Zellania Davidsoni*, Moore (Dundry) | c | ..... | ..... | ..... | ..... | ..... |
| *Laboucheri*, Moore (Dundry) | r | ..... | ..... | ..... | ..... | ..... |
| *globata*, Moore | ..... | r | ..... | ..... | ..... | ..... |
| *Oolitica*, Moore, (Dundry) | r | ..... | ..... | ..... | ..... | ..... |
| *Terebratulina Dundriensis*, Dav. (Dundry) | r | ..... | ..... | ..... | ..... | ..... |
| *Terebratula submaxillata*, Morris | ..... | ..... | c | ..... | ? | ..... |
| *perovalis*, Sow. | c | ..... | c | ..... | c | ..... |
| var. *ampla*, Buckman | s | ..... | ..... | ..... | c | ..... |
| var. *Kleinii*, Lamarck | ..... | ..... | s | ..... | c | ..... |
| *Phillipsii*, Morris | c | ..... | c | ..... | c | r |
| var. *Phillipsiana*, Walker | ..... | ..... | s | ..... | ..... | ..... |
| *ventricosa*, Zieten | ..... | ..... | r | ..... | c | ..... |
| *Buckmani*, Dav. | r | ..... | c | ..... | ? | ..... |
| var. *Buckmaniana*, Walker | ..... | ..... | c | ..... | ? | ..... |
| * *trilineata*, Y. and B. (Yorkshire) | ..... | ..... | ..... | ..... | ? | ..... |
| *Haresfieldensis*, Dav. | ..... | ..... | c | ..... | ..... | ..... |
| *sphæroidalis*, Sow. | c | ..... | ..... | ..... | c | ..... |
| *globata*, Sow. | s | c | c | c | ? | c |
| var. *Birdlipensis*, Walker | ..... | ..... | c | c | ..... | ..... |
| *Fleischeri*, Oppel | ..... | ..... | s | ..... | ..... | ..... |
| *Eudesii*, Oppel | c | ..... | ? | ..... | c | ..... |
| *conglobata*, E. Desl. | ? | ..... | ..... | ..... | s | ..... |
| *Ferryi*, E. Desl. | s | ..... | ..... | ..... | c | c |
| *Etheridgii*, Dav. | ..... | ..... | s | ..... | r | ..... |
| *Wrightii*, Dav. | r | ..... | c | ..... | c | ..... |
| *simplex*, Buckman | ..... | ..... | c | ..... | ..... | ..... |
| *plicata*, Buckman | ..... | ..... | c | ..... | r | ..... |
| *fimbria*, Sow. | ..... | ..... | c | ..... | ..... | ..... |
| *galeiformis*, M'Coy, MS. (near Minchinhampton) | ..... | ..... | r | ..... | ..... | ..... |
| {*reticulata*, Sow. (Whatley, Frome) | ..... | s | ..... | ..... | ..... | ..... |
| {*hybrida*, E. Desl. | ..... | ..... | ..... | ..... | r | ..... |
| *infra-Oolitica*, E. Desl. | ..... | ..... | r | ..... | c | ..... |
| *Stephani*, Dav. | c | ..... | ..... | ..... | c | ..... |
| *decipiens*, E. Desl. | c | ..... | ..... | ..... | c | ..... |
| *Craniæ*, Dav. | r | ..... | ..... | ..... | ..... | ..... |
| *Whitakeri*, Walker | ..... | ..... | s | ..... | ..... | ..... |

| List of Brachiopoda—*continued.* | Somerset and Dorset. | | Cheltenham. | | France. | |
|---|---|---|---|---|---|---|
| | I.O. | F.E. | I.O. | F.E | I.O. | F.E. |
| *Terebratula provincialis*, E. Desl. | ..... | ..... | ..... | ..... | c | ..... |
| *curvifrons*, Oppel | ..... | ..... | c | ..... | r | ..... |
| *Morièri*, Dav. | r | ..... | ..... | ..... | s | ..... |
| *curviconcha*, Oppel | ..... | ..... | ..... | ..... | ..... | r |
| *fylgia*, Oppel | ..... | ..... | ..... | ..... | ..... | c |
| * *Württenbergica*, Oppel (Germany) | ..... | ..... | ..... | ..... | ..... | ..... |
| * *omalogastyr*, Hehl Ziet. (Germany) | ..... | ..... | ..... | ..... | ..... | ..... |
| *Waldheimia emarginata*, Sow. | r | ..... | .... | ..... | c | c |
| *Waltoni*, Dav. | s | ..... | ? | ..... | c | ..... |
| *subbucculenta*, Chap. et Dew. | r | ..... | ..... | ..... | c | c |
| *ornithocephala*, Sow. | ..... | c | ..... | ..... | ..... | c |
| *Cadomensis*, E. Desl. | ..... | s | ..... | r | ..... | c |
| *Hughesii*, Walker | ..... | ..... | r | ..... | ..... | ..... |
| *carinata*, Lamarck | c | ..... | r | ..... | c | ..... |
| var. *Mandelslohi*, Oppel = *W. carinata*— | ..... | ..... | ..... | ..... | ..... | ..... |
| *alveata*, Quensted | s | ..... | c | ..... | c | c |
| * var. *Blakei*, Walker (Yorkshire) | ..... | ..... | ..... | ..... | ..... | ..... |
| *Meriana*, Oppel | c | ..... | c | ..... | c | ..... |
| *Leckenbyi*, Walker | ..... | ..... | r | ..... | ..... | ..... |
| *cardium*, var. *Leckhamptonensis*, Walker | r | ..... | r | ..... | ..... | ..... |
| *Anglica*, Oppel | c | ..... | ..... | ..... | ..... | ..... |
| *bullata*, Sow. | ..... | c | ..... | ..... | ..... | ? |
| *Megerlia Munieri*, E. Desl. | ..... | ..... | ..... | ..... | ..... | r |
| *Terebratella bivallata*, E. Desl. | ..... | ..... | ..... | ..... | ..... | c |
| *sulcifrons*, Benecke | ..... | ..... | ..... | ..... | ..... | c |
| *Rhynchonella frontalis*, E. Desl. | ..... | ..... | ..... | ..... | r | ..... |
| *Wrightii*, Dav. | ..... | ..... | r | ..... | c | ..... |
| *plicatella*, Sow. | c | ..... | ..... | ..... | c | ..... |
| *subtetrahedra*, Dav. | c | ..... | c | ..... | c | ..... |
| *subdecorata*, Dav. | r | ..... | s | ..... | ? | ..... |
| *quadruplicata*, Zieten | ..... | ..... | c | ..... | c | ..... |
| *Lycetti*, Dav. | ..... | ..... | c | ..... | ..... | ..... |
| *cynocephala*, Richard | r | ..... | c | ..... | r | ..... |
| *ringens*, Herault | c | ..... | ..... | ..... | c | ..... |
| *subringens*, Dav. | r | ..... | ..... | ..... | ..... | ..... |
| *Oolitica*, Dav. | ..... | ..... | c | ..... | ..... | ..... |
| *Forbesii*, Dav. | c | ..... | ..... | ..... | ..... | ..... |
| *subobsoleta*, Dav. | ..... | ..... | c | ..... | ..... | ..... |
| *angulata*, Sow. | ..... | ..... | c | ..... | c | ..... |
| *subangulata*, Dav. | s | ..... | c | ..... | ..... | ..... |
| *Smithii*, Walker | ..... | c | ..... | ..... | ..... | ? |
| *Tatei*, Dav. | ..... | ..... | s | ..... | ..... | ..... |
| *parvula*, E. Desl. | s | ..... | ..... | ..... | c | ..... |
| *Stephani*, Dav. | r | ..... | ..... | ..... | ..... | ..... |
| *spinosa*, Sow. | c | r | c | ..... | c | ..... |
| * *Crossii*, Walker (Lincolnsh. & Yorksh.) | ..... | ..... | ..... | ..... | ..... | ..... |
| *senticosa*, v. Buch. | r | ..... | ..... | ..... | c | ..... |
| * *acuticosta*, Hehl Zieten (Germany) | ..... | ..... | ..... | ..... | ..... | ..... |
| * *Stiufensis*, Oppel (Germany) | ..... | ..... | ..... | ..... | ..... | ..... |

In a quarry near the church at Misterton, near Crewkerne, I found a band of clay lying on the top of the Inferior Oolite stone, containing numerous specimens of a variety of *Waldheimia Meriana* associated with *T. decipiens*. It is probable that some of the specimens found in this district, referred to *T. Eudesii*, Oppel, may belong to *Terebratula conglobata*, Desl.

I have thought it necessary, in drawing up the preceding table, to give the species found in the Fuller's Earth as well as those found in the Inferior Oolite, as these beds are closely connected, and the division may have been drawn differently in France and in England.

*Remarks.*—The specimens which occur at Dundry are identical with those in the Sherborne district; but the small shells *Thecidea*, *Zellania*, etc., have not yet been found in the latter locality, but will be sought for the next time Prof. Buckman's quarry is worked for road-metal. Several *Thecidea*, etc., and more *Rhynchonellæ* may occur in France, but as these have not yet been described in the Paléontologie Française, the list may be incomplete. *Terebratula maxillata* and *Rhynchonella concinna* have been stated to occur in the Fuller's Earth of Sapperton Tunnel near Cirencester, but a blue band of the Great Oolite was cut through in making the tunnel, and the fossils from it were mixed with those from the Fuller's Earth, being nearly the same colour. It will be observed that the species peculiar to the Oolitic Marl of Cheltenham district, as *Rhyn. Lycetti*, Dav., *Rhyn. subobsoleta*, Dav., *Waldheimia Leckenbyi*, Walker, *Terebratula fimbria*, Sow., *Terebratula submaxillata*, Dav., etc., are wanting both in the Dorset district and in France; and that several species, as *Rh. ringens*, Herault, *Rh. parvula*, E. Desl., *Rh. plicatella*, Sow., *Rh. senticosa*, v. Buch, *Waldheimia subbucculenta*, Chap. et Dew., *W. Waltoni*, Dav., *W. emarginata*, Sow., *Terebratula decipiens*, E. Desl., *T. Ferryi*, E. Desl., *T. Morièri*, Desl. and Dav., *T. Stephani*, Dav., *T. sphæroidalis*, Sow., occur in France and Dorset and Somerset, and not at Cheltenham. Probably some Palæozoic barrier separated these two areas during the deposit of these zones, and the exact equivalents may not be able to be found on comparing the different horizons of the Inferior Oolite of these districts. The Oolite marl being absent in France and Dorset; the bed containing *Rh. ringens* has not been found at Cheltenham. It is also worthy of remark that the Brachiopoda of the other Oolitic strata, and the Lias of Somerset and Dorset contain several species which do not occur in other parts of England, but are common in France.

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## VI.—On *Meyeria Willettii*, a New Macrourous Crustacean from the Chalk of Sussex.[1]

By Henry Woodward, LL.D., F.R.S., F.G.S.,
of the British Museum.

THE genus *Meyeria* was established by Prof. M'Coy, in 1849, for the reception of certain Crustaceans from the Gault and Greensand, found at Speeton, Yorkshire, and at Atherfield, in the Isle of Wight. A new form has been most obligingly sent to me for examination by Henry Willett, Esq., F.G.S.; and this being in a more perfect state of preservation than any heretofore obtained,

[1] Originally published in Dixon and Jones' Geology of Sussex, 1878, p. 379.

enables me to refer to the same species about eight other remains from the Chalk preserved in the British Museum and including the carapace figured on pl. xxxviii. fig. 8 of Dixon's Geology of Sussex.

M'Coy considered *Meyeria* to belong to the family *Thalassinadæ:* but to this Prof. Bell demurs, considering it ought to be associated with the *Astacidæ*, the division across the exterior plate of the tail being an absolutely distinctive character of the latter family.

It will be observed that Mr. Willett's specimen, figured in the annexed woodcut, agrees more nearly in size with *Meyeria ornata*,

*Meyeria Willettii*, H. Woodw. White Chalk, Lewes. Natural size.

from Speeton, than with the much larger species, *Meyeria vectensis*, from Atherfield. The abdominal somites of our specimen, however, are not ornamented, as in *M. ornata*, with four or five transverse elevated rows of rounded granulations, but are nearly plain, as in *M. vectensis*, save that each segment is marked by two lateral grooves enclosing a somewhat raised area, and their epimera are granulated and furnished with small spines along their border, which is truncated. The median lobe of the tail is wanting, but two lateral lobes are present, the outer of which is transversely divided along the distal border. The carapace is evenly and finely granulated; the cervical furrow is nearly straight, dividing the carapace at about one third of its length from the front; the cardiac furrow is clearly marked, enclosing a broadly triangular area, the sides of which slope upwards on either hand from the cervical furrow, and meet upon the dorsal line near the posterior margin of the carapace.

Three nearly parallel ridges, with slightly more prominent granules, mark the gastric region of the carapace. A furrow, uniting with the cervical and cardiac furrows, curves around the hepatic region, and separates it from the other regions of the carapace. This part is very indistinct in Mr. Willett's specimen, but is well shown in the carapace figured by Dixon.

From Mr. Willett's specimen, and still more clearly marked in one of Dr. Mantell's, we learn that the forearms were long, slender, and bordered by small spines, the surface granulated, and the extremities monodactylous.

The four pairs of feet were long and slender, their surfaces smooth (not granulated like the forearms), and their edges bordered by small spines. Of the antennæ we cannot speak, as they have not been preserved.

The specimen figured in the accompanying woodcut[1] is from the White Chalk of Lewes, and probably Dr. Mantell's and Mr. Dixon's specimens are from the same locality. There is also a closely allied, if not identical, species preserved in the British Museum, from the Upper Greensand of Wiltshire (part of Mr. W. Cunnington's Collection), and another from near Ventnor (Chalk-rock ?), presented by Prof. T. Rupert Jones, F.R.S.

I dedicate this species to H. Willett, Esq., F.G.S., whose exertions on behalf of the Sub-Wealden Boring, the completion of the palæontology of the Chalk, and the success of the Brighton Museum, are well known to all geologists.

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## VII.—On the Occurrence of a Fossil Tree (Glyptodendron) in the Clinton Limestone (base of Upper Silurian), of Ohio, U.S.

By Professor E. W. Claypole, B.A., B.Sc. (London); of Antioch College, Yellow Springs, Ohio.

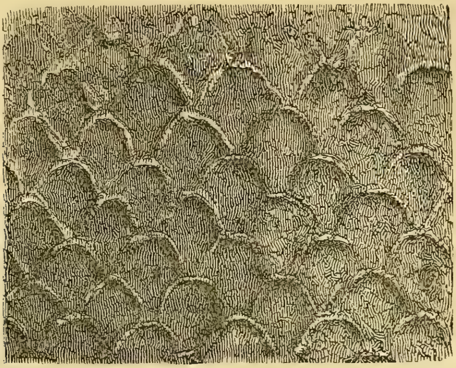
During the summer of 1877 I made a geological excursion, in company with one of my students, to the western part of our State, to examine the junction of the Upper Silurian ("Clinton" of the Ohio Survey) and the Cincinnati group of the Lower Silurian. Whilst thus engaged near Eaton, in Preble Co., my companion, Mr. Leven Siler, of that town, picked up and handed to me a slab bearing what appeared to be a mould of the well-known bark of the *Lepidodendron*, somewhat weathered. More careful examination confirmed the first impression, and convinced me that I had indisputable proof of the existence of arborescent vegetation of an earlier date than had hitherto been announced upon equally conclusive evidence.

The fossil, of which a woodcut accompanies this paper, is on the surface of a slab of marine limestone. It measures about two inches and a half, by two inches, and contains nearly fifty more or less distinct scars, such as mark the bark of a *Lepidodendron*. Its surface is cylindrically concave, and has just such an impression as a round stem would produce—that is, it represents a segment of a cylindrical surface, of the dimensions given above, and depressed about half an inch in the middle. The squeeze accurately shows both the marks and the curvature of the surface.

The slab containing it was not taken out of the solid rock, but picked up loose on the surface of a bank close to the junction of the

[1] For permission to use this illustration from Dixon's Geology of Sussex (New Edition, 1878) we are indebted to the kindness of the publisher, Mr. W. J. Smith of Brighton.

Upper and Lower Silurian beds, which are here in juxtaposition and conformable, though marked at their junction by a great palæontological break. It becomes therefore necessary to set forth the evidence for its asserted age.



The oldest known tree, *Glyptodendron Eatonense*, U. Silurian (Clinton), Eaton, Preble Co., Ohio, U.S.

In the first place the general appearance of the stone is sufficient to satisfy any one practically familiar with the locality that it belongs to the horizon above mentioned. It is a slab of yellow, coarse-grained, Encrinital limestone, considerably weathered, exactly like the limestone of that date at Eaton, and generally on the outcrop around the Cincinnati exposure. In the second place, it contains on its face one of the commonest of the Corals found in the "Clinton" of the Ohio Survey, and closely resembling, if not identical with, *Chœtetes lycoperdon* (Hall), from the Hudson River and Clinton groups in New York, and figured in the first and second volumes of the Report of the New York Survey. Thirdly, from the back of the stone I chipped out a piece containing a small *Illœnus*, the young of *Illœnus Daytonensis* (Hall and Whitfield), Clinton group, "Ohio Palæontology," vol. ii.; or possibly of *I. Varriensis* (Mur.), *I. ioxus* (Hall). As the last-mentioned genus is not recognized above the Niagara (Wenlock) Group, this specimen is sufficient to determine the age of the stone, and therefore of its contained fossil.[1]

At the outset of my examination, I was inclined to place the fossil in the genus *Lepidodendron;* but further study has convinced me that it cannot rightly be referred to that plant, and I therefore put it by itself in a new genus, thus defined :—

Glyptodendron. Tree-like stem cylindrical; surface marked with two parallel sets of ridges running spirally up the stem in opposite directions, crossing each other and thus forming rhomboidal

[1] The fossil was exhibited, and an address given upon it, at a meeting of the Natural History Society of Cincinnati on January 1, 1878. Many gentlemen well acquainted with the geology of this region were there present, and the evidence then and there submitted was unanimously considered conclusive on the age and relations of the fossil.—E. W. C.

areoles. Lower portion of each areole depressed and probably representing, or containing, a leaf-scar. Depressed portion of areole (leaf-scar?) symmetrical (*i.e.* alike on right and left sides). Vascular scars, leaves, fruit, etc., unknown. *Ety.* *γλύφω*, I engrave; from the depressed areoles.

I append the following specific description:—

Glyptodendron Eatonense. Stem thick and trunk-like, the specimen described measured, when complete, about six inches in diameter. Surface divided into rhomboidal areoles by two sets of narrow ridges, parallel and equidistant, running spirally up the stem in opposite directions. These ridges cross each other nearly at right angles. The areoles thus formed measure about seven-sixteenths of an inch along each diagonal. Lower portion of areole deeply and evenly depressed, and probably representing a sunken leaf-scar. Upper border of depressed portion rounded in outline, and elevated, equalling in height the spiral ridges. *Ety.* Eaton, Preble Co., Ohio, near which town the specimen was found.

The only species of *Lepidodendron* and of *Sigillaria* yet described from American rocks older than the Carboniferous are the following in order of time:—

*Lepidodendron (Sigillaria) Vanuxemi*, Gœppert, 1836; "Flora Silurisch." Chemung Group, New York. Figured in "Geology of 3rd District of New York," p. 184; also in Dana's "Manual," 1874, p. 277.

*Sigillaria simplicitas*, Vanuxem, 1842; "Geology of 3rd District of New York," p. 190. Catskill Group.

*Lepidodendron (Sigillaria) Chemungense*, Hall, 1843; "Geology of 4th District," p. 275. Chemung Group.

*Lepidodendron primævum*, Rogers, 1858; "Geology of Pennsylvania," p. 828. Hamilton Group.

*Lepidodendron Gaspianum*, Dawson, Quart. Journ. Geol. Soc. 1859, vol. xv. p. 483, Catskill Group. See also "Acadian Geology," 1868, p. 542; Rogers's "Geology of Pennsylvania," p. 829, fig. 677; "Geology of 3rd District of New York," p. 157.

*Sigillaria palpebra*, Dawson, 1862; Quart. Journ. Geol. Soc. vol. xviii. p. 309. Hamilton Group.

*Lepidodendron corrugatum*, Dawson, 1860; Quart. Journ. Geol. Soc. vol. xv. p. 68; from Akron, Ohio, formerly referred to the Devonian, is now regarded as of Lower Carboniferous age; Dawson's "Report on Fossil Plants of Canada," 1871, p. 34.

The following table will show the relation of this new fossil to those of the two genera, named above, previously known in America:—(see table on next page).

In 1861 Dr. Dawson mentioned the occurrence of *Psilophyton princeps* in the Gaspé Limestone of Lower Helderberg (Ludlow) age in Canada; but, from that time, the writer is not aware of the announcement of any discovery of like nature until 1877, when Dr. Carl Rœninger, State-Geologist of Michigan, discovered some specimens of land-plants in the Lower Helderberg Limestone of Monroe County in that State. These specimens were sent for determination to Mr. Leo Lesquereux, of Columbus, Ohio, who has described them to the American Philosophical Society at Philadelphia as *Psilophytum cornutum*, Lesq., and *Annularia Rœningeri*, Lesq. With these exceptions, no indisputable traces of land plants

| Carboniferous. | Lepidodendron. 50 sp.[1] | Sigillaria. 60 sp.[1] |
|---|---|---|
| Sub- or Lower Carboniferous ..... ..... ..... | 13 sp. | |
| | *L. costatum*, Lesq. | |
| | „ *corrugatum*, Dawson. | [2] |
| | „ *radioplicatum*, Dawson. | |
| | „ *aculeatum*, Stern. | |
| | „ *forulatum*, Lesq. | |
| | „ *obscurum*, Lesq. | |
| | „ *Veltheimianum*, Stern. | |
| | „ *scobiniforme*, Meek. | |
| | „ *tetragonum*, Stern.[3] | |
| | „ *Sternbergi*, L. & H. | |
| | „ *diplostegioides*, Lesq. | |
| | „ *turbinatum*, Lesq. | |
| | „ *Worthenanum*, Lesq. | |
| Catskill | „ *Gaspianum*, Dawson | *S. simplicitas* |
| Chemung | „ *Chemungense* | [4] |
| | „ *Vanuxemi* | |
| Hamilton..... ..... ..... ..... | „ *primævum* | *S. palpebra* |
| Corniferous ..... ..... .... | | |
| Oriskany ..... ..... ..... ..... | | |
| Lower Helderberg ..... ..... | | |
| Onondaga ..... ..... ..... | | |
| Niagara ..... ..... ..... ..... | | |
| Clinton ..... ..... ..... ..... | *Glyptodendron Eatonense*[5] | |
| Medina ..... ..... ..... ..... | | |
| Oneida Conglomerate | | |
| Hudson River (Cincinnati) Lower Silurian | | |

have yet been announced from the American Silurian or older rocks, in spite of their immense extent.

A specimen was, however, described by Lesquereux in 1874 ("American Journal of Science," January) as a land-plant allied to *Sigillaria.* It was found near Lebanon, Ohio, about 35 miles north-east of Cincinnati, and was thought to show faint traces of spiral marks, like those upon the stem of *Lepidodendron* or *Sigillaria.* Mr. Lesquereux remarks of the specimens (for there were two species):

"They were fragments of small stems or branches, one about two inches thick, cylindrical, the whole substance transformed into soft grey clay, the bark or outer surface only distinctly moulded into clay, and marked by rhomboidal continuous (*sic:* contiguous?) enlarged bolsters, surrounding the stem in a spiral, bearing at the middle a small oval or rhomboidal scar, less distinct, though well recognizable, and presenting the character of stems of *Sigillaria Menardi*, Br., or of *Sigillaria Serli*, Br."

Professor Newberry, remarking in the August number of the

[1] See Miller's "American Palæozoic Fossils."

[2] *S. Lorwayana*, given in the above-quoted Catalogue as "Lower Carboniferous," is from the Middle Carboniferous or Coal-measures of Cape Breton. See Dawson's Report, 1873.

[3] This species is omitted in the above Catalogue, but see Dawson's Report, 1873.

[4] *S. Chemungensis*, of the same Catalogue, is a synonym for *L. Chemungense.*

[5] Placed in this column to save space. This position is not inconsistent with the affinity of the species.

same Journal, on these specimens, says:—"They had been in my possession some time before the publication of Mr. Lesquereux's notice, and I had examined them with some care, and had also made careful drawings of them. As the result of my examination, I am compelled to say that I fail to find either in the external character or internal structure of these specimens any satisfactory evidence that they represent land-plants—still less that they form species of the genus *Sigillaria*." "They are simply casts in earthy limestone, without carbonaceous matter or any traces of woody tissue."

In the "Review of the Fossil Flora of North America," 1876, Mr. Lesquereux says:—"A few cylindrical branches or impressions of branches upon clay, bearing upon their surface rhomboidal scars, disposed in spirals around the stem, like those of *Lepidodendron*, were lately discovered in the Cincinnati group of the Middle Silurian. As they were found associated in the same strata with fragments of fucoids and deep-marine Molluscs, their relation was considered as being rather with peculiar forms of Algæ."

But in the paper above mentioned, 1877, Mr. Lesquereux reasserts the terrestrial nature of these specimens, and describes them under the name of *Protostigma sigillarioides*. The genus is thus defined. "This generic name is provisionally admitted for the description of fragments of stems, whose relation to species of *Sigillaria*, etc., is surmised from the rhomboidal form of their scars." He adds, in the introduction, that Professors Dana, Eaton, and Verrill all agree in referring the remains to land-plants. Where such distinguished authorities, with the advantage of having seen the specimens, express such opposite opinions, the matter must be considered at least doubtful.

Mr. Lesquereux also describes, in the same paper, two other specimens from the Cincinnati group. The former of these he names *Sphenophyllum primævum*, and the latter *Psilophyton gracillimum*. The opinion of so eminent and experienced a palæobotanist is entitled to the greatest respect, and the discovery of fossil land-plants of Lower Silurian age *in some parts* of America is by no means an improbable event. It is right, however, to observe that the latter of these is a fossil long known to collectors in this part of the country, and by them always considered to be identical with *Graptolithus abnormis*, Hall, from the Quebec Group of Canada. This alone will show how much uncertainty as yet attends the identification of the fossil. In regard to both the species just named serious difficulties also arise from a consideration of the physical geology of the region at the time in question, against too ready a conclusion in favour of their terrestrial origin, and especially against the probability of their occurrence near Cincinnati. During the existence of the Cincinnati Ocean of Lower Silurian date, the whole of the interior basin was under water. The nearest shores were the Blue Ridge of the Appalachian chain, on the east, 500 miles from Cincinnati—the Laurentian highlands, on the north, at about the same distance—the Huronian (?) highlands of Michigan, to the north-west—the present site of the Rocky Mountains, to the west—

and the high grounds of Texas to the south-west—all at yet greater distances. It is somewhat difficult to conceive of the preservation of a filmy frond of *Sphenophyllum* during a voyage of so great a distance, and its entombment in mid-ocean in a recognizable condition. The same objections do not apply with equal force to the preservation of a stem of a tree, if *Protostigma* was such, though it may be doubted if any other case has come to light of the discovery of undoubted fossil wood 500 miles from the nearest contemporaneous land.

In regard to the fossil described in the present paper, the case is different. About the close of the Lower Silurian age an uplift occurred along a line reaching from Ontario, in Canada, to Tennessee—the forerunner apparently of that later movement which elevated the Alleghany Mountains. This uplift was an area of dry land during the interval which, in this region, elapsed between the Lower and Upper Silurian formations. The return of the sea is marked by a conglomerate of Lower Silurian pebbles in a matrix of Clinton Limestone. "This proves that, before the deposition of the Clinton, the Cincinnati group was consolidated into rock and raised into cliffs and shore-lines, which were eaten away by the waves at the ocean-level to form a pebbly beach."—"Geology of Ohio," vol. i. p. 103. On this Cincinnati Island of Upper Silurian age there probably grew the tree of which a part produced the impression above described and named. At the same time the scarcity of such relics (no other having yet come to light), where the land was at most but a few miles distant, brings out more strongly the improbability of finding such remains in the Lower Silurian rocks of the same locality, when the Island of Cincinnati had not come into existence.

The Silurian Botany of Europe is equally scanty. The Lycopodiaceous spore-cases (*Pachytheca*, Hooker) from the Ludlow bone-bed[1] correspond, in date, with the plants from the Lower Helderberg of Michigan. The *Sagenariæ* (*Lepidodendra*) of the Upper Silurian of Lobenstein, and of Hostin, Bohemia, are of similar age. So is *Hostinella* also from Hostin.—Bigsby's "Thesaurus Siluricus," p. 194. Some plant-remains have been found in the Upper Silurian rocks of the Eastern Hartz by Ad. Rœmer, see "Siluria," last edition, p. 391. In the Geological Magazine for October, 1877, Count Saporta has described a Fern, from the Lower or Middle Silurian Slates of Angers, in France, as *Eopteris Andegaversis*. In 1859 Sir R. Murchison mentioned the existence of faint traces of terrestrial vegetation in the Lower Silurian rocks of Scotland ("Siluria," p. 169). These are all the instances with which I am acquainted of remains of land-plants in pre-Devonian rocks in the Old World. I omit *Eophyton* as far too doubtful to be cited in evidence. "The *Eophyton* of Torell, from a much lower horizon in Sweden," says Dr. Dawson, "I regard as a doubtful plant, similar forms being apparently produced by impressions of feet or of fins upon mud. . . . Whatever the nature of these forms, they are present in the Primordial of

[1] These little organisms have been of late referred to Algæ.—Editor.

America. Mr. Murray has found them in Newfoundland, and Mr. Selwyn in Nova Scotia." The *E. explanatum* of Mr. Hicks from the Lower Arenig (Llandeilo) rocks of Wales is apparently something quite different; and in microscopic structure would seem to be similar to that of the *Nematoxylon* of the Devonian, if it be a plant at all, and not a marine organism.—Dawson, "Fossil Plants of Canada," 1871, p. 79.

I desire, in conclusion, to express my obligation to Dr. J. W. Dawson, of Montreal, for valuable assistance willingly rendered, and to Mr. Leo Lesquereux, of Columbus, Ohio, for kind and prompt replies to letters of inquiry.[1]

## REVIEWS.

### I.—Memoirs of the Geological Survey of England and Wales.

1. The Eruptive Rocks of Brent Tor and its Neighbourhood. By Frank Rutley, F.G.S.
2. The Chimæroid Fishes of the British Cretaceous Rocks. By E. T. Newton, F.G.S. (London, 1878.)

THE above works on very different subjects indicate the progress of research carried on by the Geological Survey, and form valuable additions to their other publications. The first memoir comprises a description of a limited district around Brent Tor, which was surveyed nearly fifty years ago by Sir H. De la Beche, recorded in his Report on the Geology of Cornwall, Devon, and West Somerset, to which work the investigations of Mr. Rutley may be considered as a sequel. Within the district of about sixty square miles occur many highly-interesting and peculiar eruptive rocks, some intruded through, and others interbedded with, the Carboniferous and Devonian strata which lie on the west of Dartmoor. The object of the author being to elucidate (1) the mineral composition and structure of the different rocks as observed in the field, and of which a detailed account is given in the first part, illustrated by some artistic sketches of their physical features and other characters in plates 2 to 6; (2) to investigate, by means of the microscope, the more minute structure of selected specimens of the rocks, a mode of research which, during the last few years, has materially assisted the labours of the petrologist;—twenty-seven different rocks are clearly described, and some of them are beautifully illustrated by enlarged coloured figures (plates 8 to 10) from Mr. Rutley's careful microscopic drawings. The third part comprises remarks on the probable conditions under which the igneous

[1] "Proceed. American Philosophical Society" (Philadelphia), vol. xvii. No. 100, 1877, p. 163, etc., Leo Lesquereux, "On Land-plants recently discovered in the Silurian Rocks of the United States." Read October 19th, 1877; printed January 7th, 1878.

*Psilophytum gracillimum* (p. 164), sp. n.
——— *cornutum* (p. 165), sp. n.
*Annularia Romingeri* (p. 166), sp. n.
*Sphenophyllum primævum* (p. 167), Lesqx.
*Protostigma sigillarioides* (p. 169), sp. n.—Editor.

and sedimentary rocks were formed, and the conclusions arrived at from the observations made in the preceding parts (I. II.) serve to show that the views entertained by Sir H. de la Beche are in the main correct, and represent a vast amount of truth, derived simply from observations in the field.

These three parts are preceded by some useful remarks on the application of the microscope to petrological research, being the first special petrographical work issued by the Geological Survey. In this introduction the author dwells briefly upon the microscopic characters of a very few of the common minerals which help to form eruptive rocks, and of a few of the most interesting questions relating to those rocks themselves. Besides which, he points out how far the evidence to be derived from a microscopical examination of rocks can be relied on, and how far the older methods of determination formerly, and now, at the field geologist's disposal, can assist, and in some cases rival, the work performed by more elaborate appliances. This introductory essay will be a valuable guide for the student in his investigation of the mineral composition and minute structure of eruptive rocks.

2. The monograph by Mr. Newton on the Chimæroid fishes of the British Cretaceous rocks may be considered as a continuation of the description of fossil fishes published in the previous Decades of the Geological Survey, and is the result of a careful investigation of a large series of specimens in the Museum of Practical Geology, the British Museum, and other collections, which are fully acknowledged in the preface. This examination has materially increased the knowledge of this group of fishes, and enabled the author to correlate the various parts of certain known species, as well as to establish species for the reception of several new forms, or varieties related to them. As the author remarks, "Every palæontologist will appreciate the difficulty experienced in determining what differences in fossil forms should be regarded as of *generic*, *specific*, or *varietal* value. And bearing in mind the individual variations and the consequent gradual evolution of new and distinct forms, which has doubtless taken place in past times, it is obvious, that any lines of division must of necessity be drawn more or less arbitrarily, and although it is found convenient to make such divisions, yet from the very nature of the case they must be to some extent unnatural." In the historical and general remarks, the previous labours of Dr. Buckland are noticed, who first recognized (more than 40 years ago) the Chimæroid affinities of certain fossil beak-like bodies in the Mesozoic and Tertiary strata. This group was further described in two valuable memoirs, by Sir Philip Egerton (Quart. Journ. Geol. Soc. 1843–47), who established five genera which have since been universally adopted in this country.

As there has been some discrepancy between the authors who have written about fossil Chimæroids, in regard to the names given to the different parts, Mr. Newton, in his remarks on the nomenclature, has explained the terms which are employed in this memoir, and has also given in a tabular form the more important characters of the genera.

| | Callorhynchus. | Edaphodon. | Ischyodus. | Chimæra. | Elasmognathus. | |
|---|---|---|---|---|---|---|
| Mandible. | Massive. | Massive. | More or less massive. | Thin and plate-like. | An extremely thin plate. | Mandible. |
| | Symphysial surface narrow. | Symphysial surface wide, no definite ridge or groove. | Symphysial surface narrow, with groove and ridge above. | Symphysial surface very narrow, with ridge and groove. | Symphysial surface very narrow, with ridge and groove. | |
| | Distinct bony layer upon exterior near oral margin. | Usually no definite bony layer upon the exterior | Well-defined bony layer upon exterior near oral margin. | No external bony layer. | No external bony layer. | |
| | No beak tooth. | One beak tooth and occasionally a smaller one above it. | Usually one beak tooth, sometimes several. | Two or more beak teeth. | Two rows of dot-like beak teeth. | |
| | One large median tooth. | One large median tooth, sometimes divided longitudinally. | One median tooth. | One median tooth. | No median tooth. | |
| | No outer teeth; oral margin sharp. | Usually two outer teeth. | Usually two outer teeth, sometimes several small ones. | Outer teeth usually numerous and dot-like. | Numerous dot-like teeth, confined to the extreme oral margin. | |
| Maxilla. | One large median tooth divided into two processes anteriorly. | Three teeth, two inner and one outer. | Four teeth, two inner, one outer and one median. | Inner teeth variable; a series of small teeth upon the outer margin. | Maxilla not known. | Maxilla. |
| | Bony layer upon exterior near oral margin. | Apparently no external bony layer. | Bony layer upon exterior near oral margin. | No bony layer upon exterior. | — | |
| Premaxilla. | Elongated from before backwards. | More or less triangular in side view; flatter than in Ischyodus. | More or less quadrate in side view, more robust than in Edaphodon. | Much like Ischyodus in form. | Premaxilla not known. | Premaxilla. |
| | Oral surface triangular with prominent ridge near symphysis. | Post oral surface laterally expanded; no bony thickening. | Post oral region not laterally expanded and usually has a definite bony thickening | — | — | |
| | No teeth. | Oral margin has teeth. | Oral margin has teeth. | Oral margin has teeth. | — | |

The species belonging to four genera are described; three of them are British—*Edaphodon, Ischyodus, Elasmognathus*; the fourth includes a species from the Cretaceous rocks of New Zealand, belonging to the recent genus *Callorhynchus*. The twelve plates (which might have been improved) fully illustrate the descriptions, and show the correlation and characters of the different parts figured.

In comparing the prices of the above two Memoirs, there appears to be something anomalous in their respective prices, one (Memoir No. 1) being three times as much as the other, although each contains the same number of pages, and the plates of the cheaper one (twelve) exceeding both in number, fullness, and size those of the other. Whether the cost of production of the two is very different, or whether petrology ranks higher in the minds of the issue department than palæontology, and hence its greater price, or whether the latter is the more favoured science, and hence furnished at a cheaper rate, it is somewhat difficult to understand. These restrictive high prices, as Mr. Rutley's memoir and the previous ones by Mr. De Rance and Mr. Skertchly, preclude the student from possessing these real useful works.

The foregoing table of the generic characters of chimæroid fishes is taken from the author's work.

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## II.—Australian Palæontology.

A Catalogue of Australian Fossils (including Tasmania and the Island of Timor) Stratigraphically and Zoologically Arranged. By Robert Etheridge, Jun., F.G.S. Edited for the Syndics of the University Press. 8vo. pp. 240. (Cambridge: At the University Press, 1878; London: Deighton, Bell, & Co.; and Cambridge Warehouse, 17, Paternoster Row.)

The distribution of Animal and Vegetable Life in former periods of the Earth's History must always be interesting to the geologist. Any Catalogue of Fossils therefore, whether of a Formation or of a country, when carefully prepared, cannot fail to be a most useful contribution to our knowledge.

Viewed in this light, we heartily welcome the list of Australian Fossils by Mr. Robert Etheridge, jun., not only as an exceedingly convenient work of reference, but also because it exemplifies in a remarkable degree the rapid strides which the Geology and Palæontology of Australia have made within a comparatively few years.

This work was originally commenced in conjunction with his former colleague Mr. Norman Taylor, in 1868, merely with a view of carrying out more effectively their duties in connexion with the Geological Survey of Victoria, on which Mr. Etheridge was at that time an Assistant-Geologist. But the Survey (so ably conducted by Mr. A. R. C. Selwyn, F.R.S.) was abruptly concluded by the Victorian Government, before its completion, and the projected Catalogue was for the time abandoned.

It was resumed, however, by Mr. Robert Etheridge, jun., alone in 1871, and he has since continued the task until its publication in September of the present year; so that the work before us may be considered as a faithful record of Australian Palæontology up to the year 1878.

The genera and species are primarily arranged in zoological order in classes, but alphabetically under each class, for more ready and convenient reference; the whole being divided into five stratigraphical subdivisions, viz.:—Silurian, Middle and Upper Palæozoic (including the Devonian and Carboniferous), Mesozoic, Tertiary, and Post-Tertiary. All the more important references are made to each of the species, and the principal localities are also given; those works in which a detailed description or figure is to be found are denoted by an asterisk placed before them.

The great labour involved in preparing this Catalogue may be partly estimated by stating that the list includes nearly 500 genera and some 1450 species, and that the separate works, reports and papers consulted in the preparation of this Catalogue of Australian and Tasmanian Fossils amounts to more than 500 in number.

Apart from the number of papers referred to for single species, and for species identified with descriptions already published, the Chronicles of Australian Palæontology have mainly been enriched by the labours of Professor Owen, the Rev. J. E. Tenison Wood, Prof. F. M'Coy, Prof. L. G. de Koninck, Prof. P. Martin Duncan, Rev. W. B. Clarke, Prof. J. Morris, Mr. R. Etheridge, and Mr. R. Etheridge, jun., Mr. W. Carruthers, Mr. C. Moore, Mr. J. W. Salter, Prof. Dana, and Mr. Thomas Davidson.

The publication of this volume is due to the liberality of the Syndics of the Cambridge University Press, who have thus conferred a boon on the Colony of Australia and a great service to geological science by enabling the author to produce in so excellent a form this first attempt at a complete list of Australian Fossil Organic Remains.

J. M.

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### III.—Australian Geology.

1. Annual Report of the Department of Mines, New South Wales, for the year 1877. (Sydney, 1878.)
2. Remarks on the Sedimentary Formations of New South Wales. By the Rev. W. B. Clarke, M.A., F.R.S. Fourth edition. (Sydney, 1878.)

THE Report of more than 200 4to. pages on Mines and Mineral Products of New South Wales comprises the results of the explorations of the Mining Registrars and Geological Surveyors, carried on during 1877 in the different mining districts of that colony, and contains much practical and statistical information, accompanied in some cases by geological maps and sections of strata. During the year, locality maps of three of the principal Gold Fields have been completed, representing an area of about seventy-three square miles, and many valuable additions have been made to the mineral and fossil collections of the Department, and a collection has also been forwarded to the Paris Exhibition, illustrative of the mineral resources and geology of the colony. The Report states that the aggregate value of the minerals raised during the year 1877 amounts to £2,233,161 2*s.* 6*d.*, showing a considerable increase over the previous year, of which minerals, after coal, tin yielded the largest amount, £508,540, exceeding that either of gold or copper, the other metals, iron, antimony, and lead, being in far less proportions.

2. The work by the Rev. W. B. Clarke is probably the last of the published results of his labours before his death (noticed p. 379), and is only one among his many contributions to the advancement of geological science, especially that of Australia, which has occupied a considerable portion of his life. The present edition is the fourth of a series, descriptive of the sedimentary formations of New South Wales, the first of which was published in a catalogue of the natural products of the colony forwarded to the Paris Exhibition of 1867, and subsequently improved in the 2nd and 3rd editions (1870, 1876). It is now considerably enlarged, and contains much fresh information brought up to the latest period, and is dedicated to the Congress of Geologists assembled at Paris in connexion with the International Exhibition of this year. The formations noticed are, the Azoic and Metamorphic rocks, the Lower, Middle, and Upper Palæozoic rocks, the Lower and Upper Mesozoic strata, and the Tertiary rocks,—of the latter it appears that "throughout the whole of Eastern Australia, including New South Wales and Queensland, no Tertiary *Marine* deposits have been discovered. There are, however, patches of *plant deposits* which may be referred to some period of the Tertiary epoch," (p. 89.) The Quaternary formation, so interesting from the remarkable fossil remains found in it, and the recent accumulations, are noticed in the last section. In this memoir no general notice is taken of igneous rocks, but it may be stated that there is, in all the various sedimentary formations noticed, distinct evidence of the presence of igneous action, and their transmutation through such and allied agencies has left an impress on all the rocks more or less concerned.

Those interested in the comparative study of the sedimentary strata will find Mr. Clarke's paper of considerable value, as showing the results of a continued study of the fossiliferous deposits of Australia,—one of which at least, the Carboniferous formation, has been the subject of some controversy, the main points of which are fully discussed by the author, both as regards its contained fauna and flora, and its connexion with other deposits in Australasia, China and India (pp. 26-66), and which, as well as the remarks on other formations, are supplemented by fifteen appendices containing lists of fossils of New South Wales described by European palæontologists.

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IV.—The County of Edinburgh, its Geology, Agriculture, and Meteorology. By Ralph Richardson, F.R.S.E. (Edinburgh: Adam and Charles Black, 1878.)

THIS essay fulfils what the title indicates, an account of the geology, meteorology, and agriculture of the metropolitan county of Scotland, preceded by some general observations on its physical features, superficial area, subdivisions, and annual value of the estimated acreage of property. This county has long been considered a classical field to the geologist, as it presents some of the finest examples of geological phenomena, whether as connected with igneous or stratified rocks, or with physical and palæontological geology. The main formations of Mid-Lothian are Palæozoic, from the Silurian to the Carboniferous, with the associated igneous rocks, over which is irregularly spread a more or less deep covering of glacial or boulder clay.

The county of Edinburgh in regard to its agriculture takes a high position. Not only have her farmers brought this science to a standard of perfection rarely attained, but the agricultural produce and value of land in the better portions of the county are exceptionally good. The relative value of the land is clearly shown by means of colours on the agricultural map of the county accompanying this paper, and which is based on Prof. A. Delesse's "Carte Agricole de la France" noticed in this MAGAZINE (Dec. II. Vol. IV. p. 474). The annual rentals are given under nine divisions, ranging from £1 to £20 and £40 per acre, these being dependent on the nature of the soil and the favourable position of the farms, those near the metropolis being the most highly rented. The meteorology is simply considered with regard to the temperature, rainfall, and altitude, these being the three main meteorological topics of agricultural interest. This essay is certain to prove of value to those interested in the district.

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V.—MANUALS OF ELEMENTARY SCIENCE. CRYSTALLOGRAPHY. By HENRY PALIN GURNEY, M.A. Fcap. 8vo. pp. 128, with 46 woodcuts. 1*s*. (London, 1878: Society for Promoting Christian Knowledge.)

THE systematic study of scientific Crystallography has certainly but few admirers, in this country at least. "Its great importance to the chemist, the physicist, and the geologist cannot," as the author of the work which we are now noticing truly says in his preface, "be questioned." The fact is, that the subject is beset with mathematical abstruseness, and has been hitherto without suitable introductory manuals. Many students have consequently been driven to empirical systems, which are little better than the learning by rote of a number of geometrical forms. We have met with many other students whose knowledge of minerals is that only of the chemist, or even of the miner. The object of the present little work is to introduce the subject scientifically to the non-mathematical. We are at a loss to know for whom such works as the present, and Professor Clerk Maxwell's *Matter and Motion*, in the same series, are designed by their publishers; since surely the somewhat advanced students in special lines of scientific research, who alone can appreciate them, would gladly pay double or treble their price and possess the author's ideas lucidly expressed in unconfined space. These manuals, however, certainly contain a vast amount of useful matter. The two main points of merit in Mr. Gurney's book are, first, the clear, unmathematical text, supplemented by some mathematical matter in an appendix; and secondly, the natural sequence adopted for the crystallographic systems, from the simplest, viz. the Anorthic, to the most complex, the Cubic. This step, analogous to that which makes our modern geologists and biologists commence with Laurentian, Protozoa, and Protophyta, is one of the greatest philosophical importance. Had space permitted it, we should have liked a little more information on crystallogenesis, more references to the history of the science, a description of the Reflective Goniometer of Wollaston, and more detail in chapter xvii., which treats of 'the Physical Symmetry of Crystals.' In a subsequent edition we may suggest that the italicizing of all technical terms when they first occur should be more uniformly carried out, that more references to figures be inserted in the text, and that the diagrams for finding the symbol of a zone when those of two faces are known, and for finding the symbol of a face common to two zones, on pp. 23, 24, be made clearer. The term 'holohedral forms', though mentioned in the index, is only defined by implication; 'deutosystematic' on p. 72 should, we presume, be 'deuterosystematic;' and Naumann's Method of Projection is only attributed to him in the 'Contents'![1] We would particularly call students' attention to the excellent series of terms proposed by Professor Maskelyne, given on p. 54, and to Mr. Gurney's triumphant proof, on p. 59, that the three rhombohedral planes of symmetry represent the holohedral type of the system, and that the double six-sided pyramid is merely a combination of two rhombohedra. We sincerely congratulate the author on his useful contribution to science; and can only regret that the majority of those pupils whom he has, during some years, instructed in the substance of this work, have gone to India in a capacity in which science can only be the hobby of hard-worked men; so that we can hope for but little fruit from their knowledge of crystallography. G. S. B.

## CORRESPONDENCE.

### CLAY BOULDERS.

Sir,—An interesting phenomenon which may assist to explain the structure of certain argillaceous rocks is now to be observed on the Crosby shore near the River Alt.

Some time since a trench had been cut in the blue clay, which underlies the Peat and Forest Bed,[2] in a south-westerly direction across the shore. For many years this trough, though filled by the tide at springs, has remained open, with simply a deposit of sand on the bottom. I have not measured it, but I should judge the trench to have been about fifty yards long, five feet wide, and two feet deep. At the present moment it is filled up nearly to the surface with an agglomeration of rounded lumps of clay more or less compacted together. The clay boulders, for such they are, vary in size

[1] Where his name even is mis-spelt.

[2] See "The Submarine Forest at the Alt Mouth," Quart. Journ. Geol. Soc. vol. xxxiv. pp. 447–8, and other papers therein referred to.

from eighteen inches on the longer axis to the size of a bean, and from a spherical to an ellipsoidal figure.

We have not far to seek for their origin, as a visit to the lower edge of the peat frayed into a sort of subtidal cliff or series of cliffs by the encroachments of the sea shows a deposit of similar clay boulders at its base. In the neighbourhood of the trench the River Alt meandering over the shore has made great inroads on the Post-Glacial deposits, which compose the substratum, forming a subtidal river cliff of blue clay on its western margin. Lumps of this clay undermined by the currents, fall, break up into pieces, and get rolled into boulders by the action of the tide. The trench has formed a sort of trap for catching and retaining them. The clay-boulders are in contact, and become in the trench compacted together into one solid mass, so that if it were converted into rock its structure would show in some cases distinct argillaceous boulders in a sandy argillaceous matrix, and in others an imperceptible shading of the boulder nucleus into the matrix.

Simply describing the foregoing facts for the information of those interested, I leave geologists to apply the explanation to some of the conglomerates. T. Mellard Reade.

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SIR RICHARD GRIFFITH AND THE OLD RED SANDSTONE.

Sir,—The last big talk I had with the late Sir Richard Griffith was immediately before the British Association Meeting in Belfast, and it was on my work in West Galway and Mayo. Previous to it I had left my maps and sections with him to examine after explaining them. During this conversation we discussed the age of the Louisburgh Toormakeady and Croogh Moyle beds which had been examined and proved to be of Silurian age, and Griffith pointed out that the Curlew Mountain rocks and those near Firodes he always believed to be of the same age and to be about equivalent to the Dingle beds, "but I never," said he, "had time to examine them carefully, and I left them in the Old Red Sandstone because they were very like the conglomerates of the Comeraghs Galters and Knockmealdown Hills." He also pointed out that there was a decided unconformability in the rocks said to belong to the "Old Red Sandstone formation" in Ireland; while the newer rocks so called seemed to be on different geological horizons. He concluded by saying, "My work must remain as it is, but the working out of the question has still to be done," or words to that effect. Since then I have been carefully examining into the question, starting on what was suggested to me by Griffith, and the results of my labours will be found in my recently published Manual of Irish Geology. This is sufficient to say at the present, as I hope to enter fully into the history of the subject in a paper to be read before the Royal Geological Society of Ireland. G. Henry Kinahan.

Ovoca, Ireland, *5th November*, 1878.

THE FOSSIL ANOMODONTIA OF SOUTH AFRICA.

Sir,—In the Geological Magazine, p. 369, is a notice of a paper by Prof. Seeley on *Procolophon*, in which he remarked on the presence of *two distinct nares* in this fossil. At the time the fossils were sent to Professor Owen from this museum, we had not received any but specimens more or less defective, especially at the apex, but I had already requested Mr. Donald White, on whose farm at Donnybrook they have as yet only been found, to try to get some examples which would show the nostrils. This he has done; and I have now before me a specimen in which the two distinct nares are excellently shown. With regard to Professor Seeley's idea that the *Procolophon* is a parent type from which the dental modifications of Anomodontia have been derived, I would point out that Tafelberg, on which the farm Donnybrook is situated, occupies a geological position much higher than that of the Karoo-beds in which *Dicynodon* is found. Hitherto this Tafelberg, formed of horizontal beds, is the only place where *Procolophon* has been found, so that it is improbable that it can have been the parent type of the Anomodontia, without we make the assumption that it appeared at a much earlier time than that for which we have any evidence. Above the beds of the Tafelberg rise the equally horizontal and conformable beds of the Stormberg, and in neither of these, so far as I know, have any Dinosaurs or Anomodontia been found.

Albany Museum, Grahamstown, Cape of Good Hope, 12*th Sept.*, 1878.

B. J. Glanville, Curator.

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PALÆOZOIC CEPHALOPODA.

Sir,—Will you allow me to ask my brother-geologists, through the pages of your Magazine, for the loan of any examples of British Palæozoic Cephalopods which they may think of sufficient interest to be noticed in a general work on that group, or likely in any way to throw light upon the subject. Having been favoured with a Government grant in aid of the publication of a "Synopsis of British Fossil Cephalopoda," I hope very shortly to offer the first part for subscription, which will include the Palæozoic portion and be amply illustrated. I am desirous of making it as complete an account of our British fauna as possible, and this can only be done by the kind co-operation of those who have valuable specimens in their collections, which, if entrusted to me, I need hardly say, will be returned in good condition.

11, Gauden Road, Clapham, S.W. J. F. Blake.

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THE BOULDER CLAY OF YORKSHIRE.

Sir,—Until recently, I was not aware that the existence of shells in the "Purple" Boulder-clay north of Flambro (the "Purple clay without chalk" of Mr. S. V. Wood), had already been pointed out in a paper by Mr. Leckenby "On the Boulder-Clay of East Yorkshire," Brit. Assoc. 1864, and more recently by Dr. J. Gwyn Jeffreys in a "Note on the so-called Crag of Bridlington" (Rep. Brit. Assoc. 1874). By a clerical error, the wrong initials have been affixed to my name in the paper published in your last Number, p. 509.

Bridlington Quay, *Nov.* 16*th*, 1878. G. W. Lamplugh.

## PROFESSOR ROBERT HARKNESS, F.R.S., F.G.S.

BORN 28TH JULY, 1816. DIED 4TH OCTOBER, 1878.

(WITH A PORTRAIT.)[1]

Those who have taken an active part in geological science during the last quarter of a century must have been profoundly impressed by the large number of notable geologists who have passed away within that period.

But the cause may readily be discerned when we remember that our science has only occupied a recognized position for about fifty years, and that the young men, who were then its most active promoters, have to a large extent fulfilled their allotted three-score years and ten within this period, affording ample testimony to the healthful nature of geological pursuits.

In a few instances, we have lost from our front ranks men whom we had hoped to see still in their accustomed places for years to come; but such special losses may have arisen from overwork hastened by organic disease; and it is to be feared that this was most probably the case with our late lamented friend Professor Harkness.

Born at Ormskirk, Lancashire, July 28th, 1816, Robert Harkness was sent at an early age to the High School, Dumfries, where under Dr. Duncan's care he received his primary education. Subsequently he entered the University of Edinburgh, and here he seems to have acquired his first love for geological science while attending the lectures of Professor Jamieson and Professor James D. Forbes. After the completion of his academic studies, he devoted himself entirely to his favourite pursuits of chemistry and geology.

Mr. Harkness's earliest researches seem to have been directed to the investigation of that most attractive field of study to geologists, the Carboniferous formation, his first paper being on "The Climate of the Coal Epoch," read before the Manchester Geological Society, in April, 1843.

It is interesting to read the views of Harkness in this paper, and to find them reiterated most remarkably by Professor T. Sterry Hunt, twenty-four years later.[2]

Mr. Harkness writes:—

"From the foregoing observations it is evident that from the first dawn of animal life, and probably also during the countless ages which preceded the creation of organized beings, till the period when terrestrial animals were first called into existence, the earth possessed a warmer and a much more equable climate than at the present time. This equable climate appears to have resulted

[1] For permission to reproduce this likeness of the late Prof. Harkness, the Editor is indebted to the kindness of the proprietors of *The Illustrated London News*.

[2] See "The Chemistry of the Primæval Earth," a lecture by Professor T. Sterry Hunt, F.R.S., F.G.S., GEOL. MAG. 1867, Vol. IV. pp. 365–366.

*Robert Harkness Esq., F.R.S., F.G.S.,*

*Late Professor of Geology, Queen's College, Cork.*

from the great density of the atmosphere which then surrounded the globe; a density originating from the great quantity of carbonic acid gas diffused through the atmosphere, and destined to support that luxuriant vegetation which clothed the surface of the earth during the coal era, and which is now deposited amongst the strata which constitute the solid crust of the globe. This dense atmosphere, from its capacity for absorbing heat, prevented, during the period when the solar rays fall most obliquely on any part of the earth's surface, the dissipation of that heat acquired by the earth during the time when the sun's rays fall most directly, and consequently prevented the occurrence of that degree of cold which is so common to our present climate. By this means, most probably, have regions which are at present clothed with ice been rendered fit for the abode of plants, which indicate a tropical climate; and to this cause may be attributed that uniform temperature which existed during the earlier geological epochs, and which we are justified in supposing to have prevailed from the extensive geographical distribution of analogous forms of extinct vegetables."

In the same year (1843) Mr. Harkness communicated to the Geological Society of London a paper, "On Changes in the Temperature of the Earth, as a Mode of accounting for the Subsidence of the Ocean, and for the consequent Formation of Sea-beaches above its present Level." But it must not be supposed from this that Harkness was merely a theoretical geologist; on the contrary, it was, as his papers testify, in the field that he excelled. Even in these early years we find him in the Coal-measures exploring and demonstrating with Mr. Binney the connexion between Sigillarian stems and Stigmarian roots at St. Helen's; tracing reptilian footprints in the Bunter of Cheshire, and Dumfriesshire; working out the Silurians of Dumfriesshire and Kirkcudbrightshire, and describing fourteen species of Graptolites discovered by himself in a country hitherto very little explored, and where fossils were not known to exist.

It is not surprising to find him, when a candidate for the Chair of Geology in Queen's College, Cork, in 1853, supported by Prof. Jamieson, Lieut.-Col. Portlock, Professor James Nicol, Hugh E. Strickland, Sir H. T. de la Beche, Sir W. Jardine, Prof. Phillips, Prof. Williamson, J. Beete Jukes, and many others. He was appointed to succeed Professor Nicol in that year, but his duties in Queen's College did not deprive geology of his active labours in the field; he simply added new explorations to his former areas, and we find him at work, "On the Geology of the Dingle Promontory, Ireland"; "The Lignites of the Giant's Causeway"; "The Devonian Rocks around Cork"; "The Serpentines of Connemara"; "The Annelide Tracks of County Clare"; and many other subjects in connexion with Irish geology; "On the Silurian Rocks of Cumberland and Westmoreland"; "The Permians of the North-West of England"; but it was especially the geology of the Lake District latterly which engaged his attention.

About 1876 the syllabus for the Queen's Colleges in Ireland was altered, and Prof. Harkness found himself no longer merely Professor of Geology, but required to lecture on Physical Geography, Geology, Mineralogy, Palæontology, Zoology, and Botany! He complied with the new regulations for 1877 and 1878, but he was overworking himself, and being warned by premonitory symptoms of heart disease, he resolved to resign his Chair at Cork, and rest quietly with his sister in Penrith, where for some years he had made his home. This he had done just previous to his last visit to Dublin in October which proved fatal.

One[1] who was intimately acquainted with Professor Harkness and his labours thus writes:—

"It is now some five-and-thirty years since the name of this able geologist first appeared as a writer on his favourite science. During this long period he had explored, on foot, the geology of large districts in the north of England, in Scotland, and in various parts of Ireland. The reports of the British Association and the Quarterly Journal of the Geological Society bear witness to his industry and to the painstaking minuteness of his method of investigation. To him we owe our earliest exact information regarding the correlatives of the reptiliferous sandstones of Dumfriesshire and Cumberland. It was his patient labours continued year after year over ground most difficult to unravel, that led the way to the working out of the structure of the Silurian uplands of the south of Scotland. To his research, too, is due the identification of the metamorphic rocks of the north-west of Ireland with those of the west of Scotland. To the elucidation of every one of the Palæozoic system of deposits he has contributed something of value.

"But important as was his scientific work, it had not a wider and more hearty recognition among his brother geologists than his own admirable qualities of head and heart. Who that has been privileged with his friendship will not cherish the memory of his earnestness over even the driest of details, his quiet enthusiasm, his generous admiration for the work of others, his unfailing cheerfulness? Who will forget that beaming ruddy face, never absent from the platform of Section C at the British Association meetings, always ready to rise among the speakers there and to reappear at the festive gatherings in the evening? There have been men who have graven their names more deeply on the registers of scientific thought and progress, but there have been few whose sunny nature has more endeared them in the recollection of their friends than Robert Harkness."

Professor Harkness was the author of sixty-three papers, six of which were joint productions (1) with Mr. John Blyth, (1) with Edward W. Binney, F.R.S., (1) with Dr. Henry Hicks, (1) with Sir Roderick I. Murchison, (2) with Prof. H. Alleyne Nicholson. Eight of his papers have appeared in the pages of the Geological Magazine, but they are for the most part in the Quarterly Journal of the Geological Society and the Reports of the British Association.

[1] Professor A. Geikie, F.R.S., "Nature," Oct. 10, p. 628.

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