640 to Part

THE

GEOLOGICAL MAGAZINE.

NEW SERIES.

DECADE II. VOL. II.

JANUARY—DECEMBER, 1875.

THE

GEOLOGICAL MAGAZINE:

OR,

Monthly Journal of Geology:

WITH WHICH IS INCORPORATED

"THE GEOLOGIST."

NOS. CXXVII. TO CXXXVIII.

EDITED BY

HENRY WOODWARD, 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 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, F.G.S., &c., &c.,

AND

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

NEW SERIES. DECADE II. VOL. II.
JANUARY—DECEMBER, 1875.

LONDON:
TRÜBNER & Co., 57 AND 59, LUDGATE HILL.
F. SAVY, 77, BOULEVART ST.-GERMAIN, PARIS.
1875.

HERTFORD:
PRINTED BY STEPHEN AUSTIN AND SONS.

LIST OF PLATES.

* *To the Binder.*—By an oversight two plates are numbered each Plate VII. and two are numbered each Plate VIII. (see above). *The Binder is particularly requested* to observe the titles of these plates, so as to avoid their being transposed or otherwise misplaced.

LIST OF WOODCUTS.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. II.

No. I.—JANUARY, 1875.

ORIGINAL ARTICLES.

I.—Contributions to the Study of Volcanos.

By J. W. Judd, F.G.S.

Introduction.

THE study of the nature and causes of the phenomena of volcanic activity, which for some time previously seemed to have almost fallen into abeyance, has during the last few years attracted the attention of many patient observers and earnest thinkers. In proof of this statement, we need only point to the valuable essays upon the subject which have recently been published by Dana, James Hall, Le Conte, Shaler, Hilgard, Sterry Hunt, and others in America, and to those by Mr. Mallet, Captain Hutton, the Rev. O. Fisher, and others in this country.

But while we cannot but regard with pleasure the revival of research in this important department of geological inquiry, it will be well not to overlook a source of danger in the direction which it seems to be almost exclusively taking.

The earliest speculations on the subject of Vulcanology belong to the domain of Cosmogony, rather than to that of Geology. With the smallest basis of knowledge of the actual phenomena of volcanic activity, theorists sought to build up "Systems of the Earth," in which recourse was freely had to igneous action to accomplish all such operations which were felt to be necessary for the removal of the difficulties of their hypotheses.

During the latter portion of the last century, however, the accurate study of the phenomena presented by active volcanos was commenced by Sir William Hamilton, Dolomieu, and Spallanzani, in that district of Europe where they are most admirably displayed, namely, Southern Italy. A little later Hutton, with his able coadjutors and exponents, Sir James Hall, Playfair, and Macculloch, sought to apply the phenomena of active volcanos to the explanation of the appearances presented by those ancient rocks, in which the signs of igenous action were clearly visible; and in no country could they have been more favourably situated for carrying on such researches than in Scotland.

In the two schools which we have thus noticed as taking their rise at no distant date from one another, in Italy and Scotland respectively, we have an indication of the two branches of inquiry into which the study of Vulcanology must necessarily tend to flow. A suggestive comparison may be draw between the investigation of volcanic action on the earth and that of vital action in the human body. In either case our opportunities for *direct experiment* are comparatively few; and in both, therefore, we are compelled to resort to indirect means in order to attain the desired results. To acquire an understanding of the nature and causes of vital action, one class of inquirers—the Physiologists—study the phenomena presented by the living body as it performs its various functions; while another class—the Anatomists—examine, in the dead subject, the machinery by which the various processes are carried on, and the structure which is built up by their operations. As in Biology, so in Geology, we have inquirers investigating, by the aid of mathematics, physics, and chemistry, the movements, products, and other attendant phenomena of volcanic activity—the Physiology of the Earth; while others devote themselves to researches connected with the position and relations of the masses which constitute it—the Earth's Anatomy; and these latter find in the ruins of extinct volcanos, and the intrusive masses connected with them, alike the mechanism and the products of igneous activity. There is, indeed, this difference between the study of the Anatomy of the *Microcosm* and that of the *Macrocosm*—that, while in the former we are able by dissection to examine the structure of its parts at our will, in the latter we can only attain our object by taking advantage of those revelations of its interior, effected by the conjoint action of subterranean movements and surface denudations.

It will not, perhaps, be doing violence to our comparison, if we venture to push it one step farther, and to remark that, as the progress of Biology has in recent years been very greatly furthered by the microscopic study of the minute tissues of which organized bodies are composed, so a new department of Geology has arisen—Micropetrology, the homologue of Histology—which promises equally to advance our knowledge of the origin, nature, and succession of those series of changes which constitute the "life of the globe." The study of the internal structure of rocks by the aid of the microscope, the initiative to which was given in 1858 by Mr. Sorby's remarkable paper "On the Microscopical Structure of Crystals, indicating the Origin of Minerals and Rocks," has recently, in the hands of Zirkel, Forbes, Vogelsang, Rosenbusch, Allport, and a host of other enthusiastic observers, made most prodigious strides, and promises to afford the most valuable aid to geological research.

The first attempt at a general treatise on Vulcanology was that of Mr. Scrope in 1825. Unfortunately, while following out the two lines of inquiry which we have just indicated, and attaining many important results, the correctness and value of which have been established by subsequent investigations, the author permitted himself to be drawn aside from the true paths of geological inquiry into the speculations of Cosmogony. No one was more conscious of this blemish of his work than the author himself, as was shown by the subsequent publication of his well-known work, "The Geology and Extinct Volcanos of Central France," in which this error is most carefully avoided; and also in a second edition of his general treatise, in which the speculative portions are omitted. In the latter he has confined his researches within the true limits of geological inquiry, and the work remains the most complete and masterly treatise on the subject which has yet been produced.

In the "Principles of Geology" due weight has been assigned by Sir Charles Lyell to igneous action in producing the existing features of the globe. In order to illustrate the manner in which the phenomena presented by the rocks of the globe are capable of explanation by the operations now taking place on its surface, both the "physiological" and "anatomical" branches of the subject are treated with that force of argument, that justice of illustration, and that felicity of language, with which every geologist is familiar. Mr. Darwin's works on South America and the Volcanic Islands of the Atlantic may be regarded as additional and very valuable illustrations of the "Principles of Geology," the work which, as he has himself assured us, first led him into those lines of research in which he subsequently attained such preeminent success.

During the last fifty years innumerable very valuable contributions to both branches of the science of Vulcanology have been made. Geographers and travellers, physicists and chemists, mineralogists and petrologists, have accumulated the most valuable details, illustrating the nature and distribution, the characters and materials, the phenomena and products of active volcanos. Humboldt, von Buch, Hoffmann, Junghuhn, and others have occupied themselves with their general features; Gustave Rose, Abich, Scacchi, vom Rath, and Fuchs, with the rocks of which they are composed; and Daubeny, Deville, Fouqué, and Janssen, with the chemical operations taking place within them.

Equally valuable have been the labours of those physical geologists who have supplied us with detailed descriptions and accurate maps, illustrating the features presented by the older igneous rock-masses and their relations to the stratified deposits with which they are associated. Foremost in this category we must mention Charles Maclaren, who at so early a date described with admirable clearness the volcanic rocks in the neighbourhood of Edinburgh. The maps and memoirs of the Geological Survey, especially those relating to North Wales and Central Scotland, also afford very valuable illustrations of the older volcanic rocks.

In some of the latest researches on Vulcanology, to which I have referred at the commencement of this article, however, a tendency is shown towards abandoning these safer methods of inquiry, based on the doctrine of Uniformity, and reverting to the earlier methods—in effect, to the substitution of Cosmogony for Geology. In the ingenious theory elaborated by Mr. Mallet a still bolder course is adopted, and, almost entirely ignoring the results of geological inquiry, this author endeavours to build up on the foundation of the nebular hypothesis of Laplace, and by the aid of those laws of Physics which he regards as fully established, a system of "Vulcanicity." Had the Physical Sciences attained their final stage of development, Mr. Mallet might perhaps have been justified in taking such high ground as he does in dealing with one of the natural sciences; but when we find that not a few of the data and principles of calculation on which he relies are disputed by authorities of equal eminence with himself in their special departments, geologists may be forgiven for thinking that the tone assumed by him in dealing with this subject was scarcely warranted. Nor is their confidence in the value of his speculations increased, when they find him arriving by means of them at conclusions totally at variance with the clearest results of geological observation,—such, for example, as that ordinary explosive volcanic eruptions did not take place during the Palæozoic period!

We are far from denying the advantage of inquiries and speculations of this character. It cannot but be of interest to the student of Geology, and at the same time calculated to afford him suggestions in the carrying out of his investigations, to see how far the conclusions at which he has arrived by direct observation can be made to harmonize with the hypotheses based on the latest results of Physical Science. But, as these latter are continually undergoing modification and development from the progress of research, we must ever be on the guard against allowing such theories to have undue weight, or being supposed capable of replacing the methods of geological inquiry, at first so well developed by Hutton, and afterwards so clearly illustrated by the labours of Lyell, Scrope, and Darwin—methods based on the principle that the explanation of the phenomena of the past can only be obtained by a study of the operations which are still going on around us.

In giving a series of sketches of the structure and phenomena of some of the most interesting volcanic districts in Europe, we shall endeavour, as far as possible, to avoid all subjects of a purely speculative character, and it will be our chief aim to direct especial attention to those features which suggest analogies with the volcanic formations of former geological periods, and appear to be calculated to throw light on the nature and succession of those operations by which these latter have been originated. While dwelling, however, upon the more general features of geological structure and igneous action, in our descriptions of the several districts, we shall endeavour not to lose sight of any of those results of chemical, mineralogical, or microscopical research which appear to throw light upon the subjects of our studies. Our object, in short, will be to confine these studies within what we have indicated as being the most important and legitimate paths of geological inquiry,—namely, the investigation of the structures and operations of extinct and active volcanos, with a view to arriving at the laws which have governed the developments and manifestations of igneous forces, alike in past geological periods and during the existing epoch.

I.—The Lipari Islands.

There is certainly no district in Europe, and perhaps none in the whole world, which affords such beautiful illustrations of the phenomena of volcanic action, and at the same time offers such remarkable facilities for their investigation, as the little group of

Mediterranean islands lying between the Phlegræan Fields of Calabria and Sicily. Etna, it is true, presents us with the monuments of igneous forces acting upon a grander scale, and Vesuvius excites a livelier interest by its historical associations, its fossil cities, and its proximity to a splendid capital; but neither of these volcanos can vie with those of the Lipari Islands, either in the remarkably suggestive features of their structure, in the permanent and interesting characters of their operations, or in the variety and beauty of their products.

Nor have the advantages here presented to the geologist been neglected by the pioneers of our science. Sir William Hamilton, Dolomieu, Spallanzani, and Scrope have, by the study of their active and extinct vents, contributed much towards our knowledge of the *modus operandi* of volcanic forces; Hoffmann, Allan, and Abich have described the interesting rocks of which the Lipari Volcanos are composed; while the last-mentioned author, with Daubeny, Charles Ste.-Claire Deville, Fouqué, and Janssen, have investigated the nature and products of the chemical actions going on within them.

The geological interest attaching to the volcanos of the Lipari Islands has induced the French Academy to send out, on several different occasions, commissions charged with their investigation. Many undertakings, which in other countries require an appeal to the resources of the Government, are in our own safely left to individual enterprise; and Mr. Scrope, who more than fifty years ago experienced and called attention to the advantages which the Lipari Islands offer as objects of study, has furnished several students of volcanic geology, myself among the number, with the opportunity of carrying on researches in them.

As no general sketch of the geology of the Lipari Islands has been published since the admirable, but now somewhat obsolete, work of Friedrich Hoffmann, which made its appearance in 1834, it has been suggested to me that an account of some of the results of my own studies there in the spring of 1874 would be of interest to the readers of this Journal. The sketch which we are here able to give must, of course, be mainly descriptive, and it will be impossible, within its limits, to enter into detailed discussions of those numerous problems of volcanic geology, towards the solution of which this interesting group of islands affords such valuable materials.

The name by which this group of islands (a Sketch-map of which is given on page 7) is generally known is derived from its central, largest, and most populous member. An earlier designation, and one which is still often applied to them, is that of "the Eolian Isles," and there is a curious interest attaching to its derivation. The original Eolus appears to have been a prince or chief of the Greek colony which inhabited these islands, and, being probably a man of superior intelligence and shrewdness, he seems to have acquired some fame by employing the two active volcanos of his dominions as natural "weather-glasses." Stromboli is still believed by the Liparotes to respond, like a barometer, to changes of atmospheric pressure; and the characters of the vapour-clouds which rise both from it and from Vulcano are, unquestionably, indicative of hygrometric variations. The power of forecasting events is, by the vulgar mind, often confounded with that of bringing them to pass; and the hero or prophet of one generation becomes the demigod of the next, and the deity of succeeding ones. Hence it is not surprising to find Eolus invested, in later mythologies, with the dignity of "God of the Winds." Such is the account of the origin of the name as given by some eminent Italian scholars; but those who have experienced the fierce and sudden storm of the seas surrounding the Eolian Isles may perhaps be disposed to adopt a simpler explanation of the identification of these islands with the blusterous deity.

The group of the Liparis consists of seven inhabited islands and a great number of small islets and rocks. The whole of these are entirely composed of volcanic materials, and two of the islands, Vulcano and Stromboli, contain still active vents; in the others, craters and lava-streams, in various stages of freshness or ruin, testify to the former scale of igneous operations within them; while active fumaroles and hot springs indicate forces not yet wholly subdued.

In describing the geological structure of the Lipari Islands, it may be well to notice the several rock-masses in what appears to be their chronological order of formation. As in the case of the classical district of the Auvergne, this order of succession in the volcanic outbursts is sufficiently indicated by the varying extent to which the different formations have suffered from denuding forces, and the relations which they everywhere maintain towards one another.

A careful study of the district seems to prove that at one time there existed a great central volcanic mountain, now, like the volcano of Santorin in the Ægean sea, in great part submerged, and reduced to a few islands representing the crater ring. Radiating from this great central volcano, three fissures appear to have been originated, and at various points along these fissures volcanic cones were thrown up, and numerous eruptions took place. Finally, the apparently dying energies centred in this volcanic district have become localized at two almost extreme points, giving rise to volcanos so opposite in their mode of action and in the characters of their products, as to suggest questions of the highest interest to the geological inquirer. It must of course be borne in mind that these three periods of volcanic outbursts, though sufficiently well characterized for the purposes of geological classification, are merely different phases in the display of the same igneous activity; and that, as they do not appear to have been separated by periods of quiescence, they are by no means sharply and clearly divided from one another.

While Stromboli stands unrivalled as an example of a volcano in the phase of permanent moderate activity, offering facilities for quiet study, (of which the distracting sensations of overwhelming grandeur and personal danger can scarcely fail to deprive the observer, in the cases of volcanos in more violent stages of eruption), Vulcano furnishes us with a most admirable and easily accessible

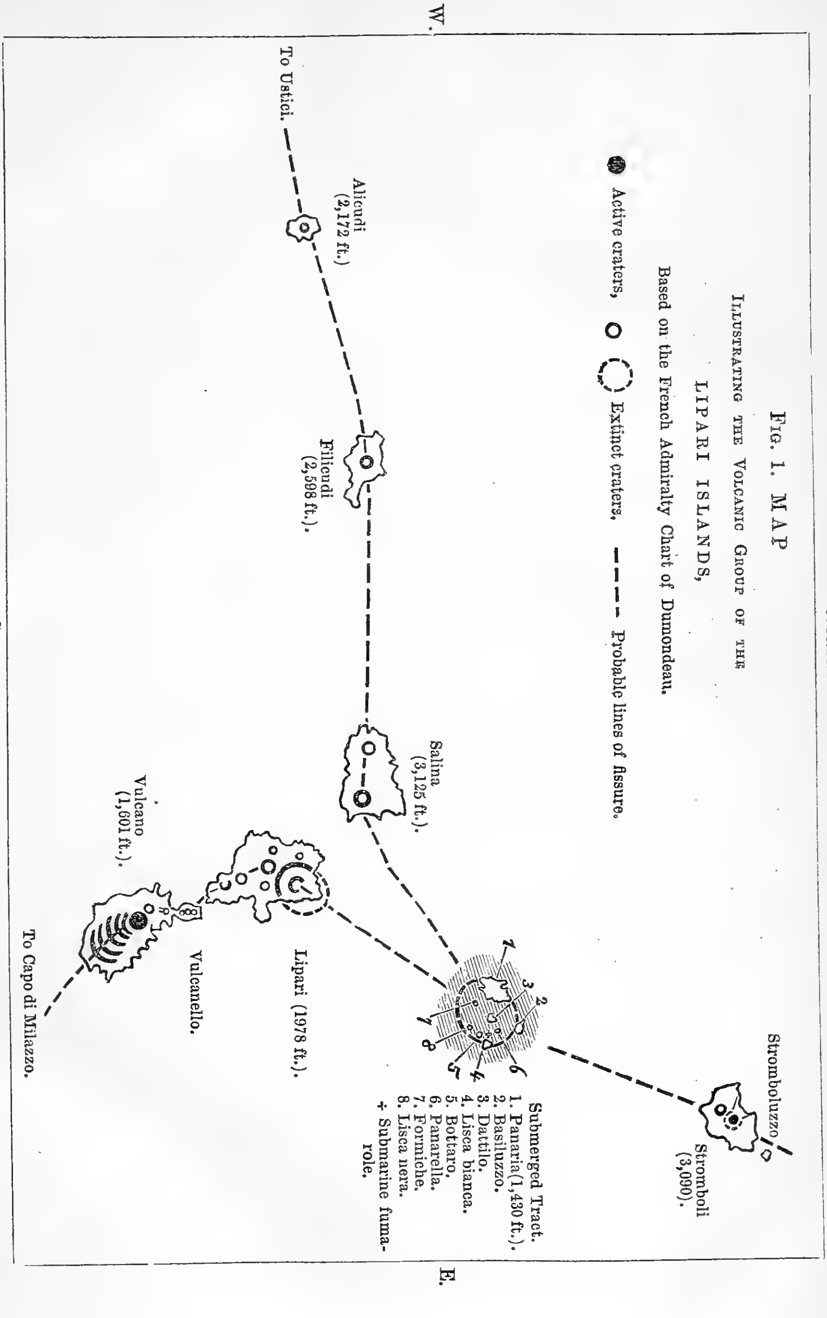


Fig. 1. MAP Illustrating the Volcanic Group of the LIPARI ISLANDS, Based on the French Admiralty Chart of Dumondeau.

crater, in the Solfatara condition, remarkable alike for the abundance and variety of its gaseous emanations, and for the beauty of the minerals which result from them, but at the same time subject to paroxysmic outbursts on the grandest scale. In all the islands we find the most beautiful illustrations of the constant shifting of centres of volcanic action along lines of subterranean fissure, and the most instructive examples of the wide diversities in the characters of lavas, from those of the most highly silicic or acid composition to those of the most ferruginous and basic, and from the highly crystalline varieties on the one hand, to perfect glasses on the other.

The analogy between the relations and order of formation of the great central volcano and the surrounding lines of volcanic vents in the Lipari Islands on the one hand, and the ruined volcanos of Central France, namely, the Mont Dore, the Cantal, and the Mezen, and the long chains of "Puys" surrounding them, on the other, must strike every student of volcanic geology, and is a sufficient justification for our adopting the following order in our descriptions of the Lipari volcanic formations:—

I. The great central volcano now almost entirely submerged, and of which we have only a few highly ruinous relics in Panaria and the surrounding islets.

II. The chains of extinct and more or less degraded cones which constitute the larger part of the other islands.

III. The very remarkable features and the interesting products of the still active or but recently extinct vents in Stromboli, Lipari, Vulcano and Vulcanello.

IV. Our sketch of the district will appropriately conclude with descriptions of the remarkable phenomena exhibited by Vulcano and Stromboli respectively, and a history of the changes which have taken place within them during the periods concerning which we have authentic records.

1.—*First Period of Volcanic Activity in the Lipari Islands.*

The submerged tract (see Map, p. 7) which marks the probable site of a great central volcano in the Lipari Islands is composed—judging from the nature of the islands and rocks which still rise above the sea-level—of various materials of the trachytic class. These occur in the form of tuffs and agglomerates, of lava streams, and of solid masses of enormous dimensions, which appear to have been extruded in a viscid or pasty condition in the manner so common with rocks of their class.

In the disposition of the materials in this central group of islets the student of volcanic geology at once recognizes those forms so characteristic of partially submerged and greatly denuded crater rings, which are so well exemplified in the ruined volcanos of Santorin in the Ægean Sea, and of Ventotiene, one of the Ponza Islands (*vide* Scrope's 'Volcanos,' 2nd ed. p. 209). As shown in the sketch (Fig. 2), the inclined streams of lava, with their alternating beds of tuff, which doubtless once constituted the sides of a great cone, gradually built up by their successive emission, now exist only as

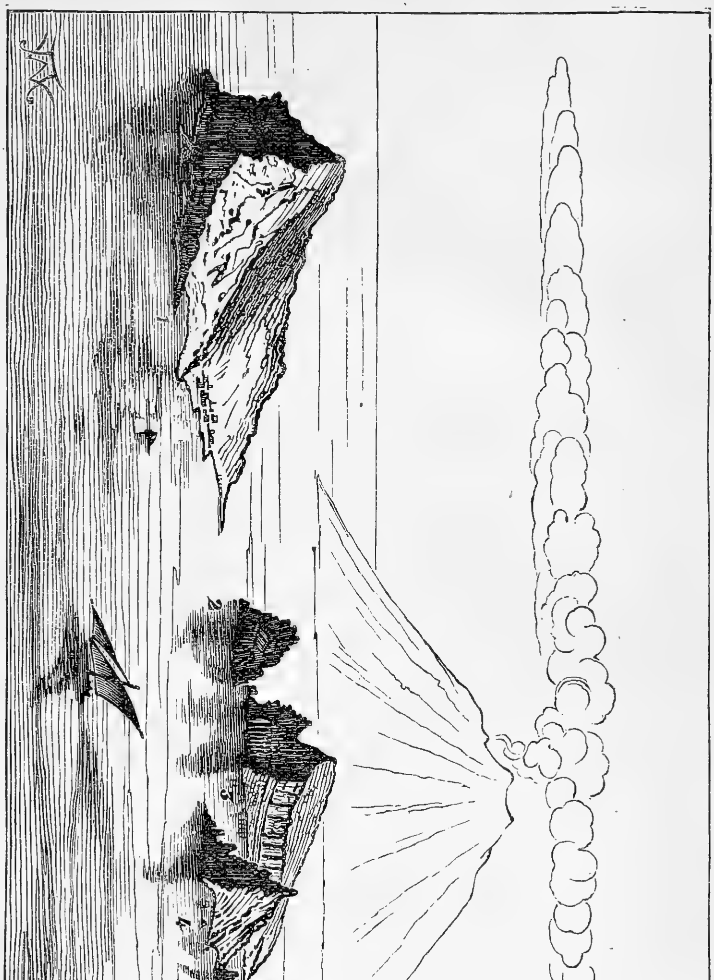


FIG. 2.—Panaria and the surrounding Islands, as seen from Monte della Guardia in Lipari.

1. Panaria. 2. Spinazzola. 3. Basiluzzo. 4. Dattilo. 5. Bottaro. 6. Lisca bianca. 7. Stromboli, seen in the distance from the South.

isolated fragments, such as Basiluzzo, Dattilo, Bottaro, Lisca nera, and Lisca bianca, each of which presents the peculiar wedge-like forms so characteristic of the denuded segments of old crater rings. Some of the lava masses in this tract, especially those of Basiluzzo and Dattilo, exhibit a rudely columnar structure. Panaria was supposed by Dolomieu to afford traces of an old crater in its central valley, but this point seems to me, at best, very doubtful. The great mass of highly crystalline rocks of which this island is composed is probably, like the central trachytic bosses of Astroni and Rocca Monfina, to which it presents striking resemblances in chemical and petrological characters, the product of an outburst of highly viscid materials which have accumulated immediately around the volcanic vent, instead of flowing as lava streams; this result being due, as in the analogous examples of the domitic puys of Auvergne, to the imperfect liquidity of the rock at the time of its emission.

The lavas of the central volcano of the Lipari Islands have long been celebrated for their remarkable petrological characters. Composed of one or more species of felspar, with hornblende or mica, and some free quartz, their highly crystalline character led some of the early observers to class them as granites. On the other hand, that they were erupted near the surface, and in many cases under no very great pressure, is shown by the glassy and pumiceous characters which portions of their mass assume. Hence they have been described as exhibiting all the transitions from granite to pumice.

In their chemical characters these peculiar rocks offer points of as great interest as in their petrological structure. From true or ordinary ("quartzfrei") trachytes, with a specific gravity of 2·6, and an average per-centage of silica of about 62, they graduate in one direction up to the rocks designated by Abich as trachy-dolerites, with a specific gravity of 2·75, and a silica per-centage of 57; while in the other, by exhibiting a smaller specific gravity with a higher per-centage of silica and some free quartz, they approach the quartz-trachytes. These extremes of composition are exhibited in the rocks of Lisca nera, Lisca bianca, and Dattilo, on the one hand, and in those of Basiluzzo on the other. They are illustrated by the following analyses made by Abich:—

	Lava of Lisca nera, etc.	Lava of Basiluzzo, etc.
Specific gravity	2·7752	2·4008
Silica	57·67	67·09
Alumina	11·94	17·36
Oxides of Iron and Manganese ...	6·71	0·81
Lime	7·72	1·23
Magnesia	7·02	1·20
Soda	} not	4·10
Potash	} determined.	8·27

Two specimens of trachyte taken from Panaria were determined by the same geologist to have specific gravities of 2·6754 and 2·7225, and per-centages of silica of 64·37 and 61·39 respectively. A third variety from the same island was found to closely approximate to the rock of Basiluzzo in composition.

From these analyses it appears that the central volcano of the Liparis, so far as its rocks are open to our observation, consists of various trachytic materials approximating to, but never reaching, the basalts on the one hand, and the quartz-trachytes on the other.

The only signs of volcanic activity still exhibited by this vast central volcano, the antiquity of which is sufficiently indicated by its greatly denuded and altogether ruinous condition, consists in an insignificant sub-aerial *stufe*, in the island of Panaria, and a submarine *fumarole*, situated in the channel between Lisca nera and Lisca bianca. The occurrence of this still active vent of volcanic energy in the midst of the submerged and altogether ruined crater of the Liparis may be paralleled with that which exists in the midst of the similar crater of Santorin, which is, however, in a far more violent stage of action, and has given rise to eruptions that have attracted so much attention during the last few years. The submarine fumarole of the Liparis, which is opened in the white pumiceous rocks of the sea-bottom at a depth of 25 feet from the surface, pours forth considerable quantities of carbonic acid and sulphuretted hydrogen gases, the bubbles of which produce a beautiful effect in rising through the clear blue Mediterranean waters and cause the sea to appear in a state of ebullition. As an amusing instance of the power of imagination, we may mention that in a recently published and popular book of travels, the authoress describes in very graphic language the sensations of scalding which she experienced on thrusting her hand into this "boiling water"!

2.—*Second Period of Volcanic Activity in the Lipari Islands.*

Turning our attention to the second period of igneous activity, which has been characterized in the Lipari Islands, we find that we shall have to refer to it by far the larger portion of the rocks of the group. Constituting the entire masses of the islands of Salina, Filicudi, and Alicudi, they form also the basis of those of Lipari, Vulcano, and Stromboli, in which, however, they are to some extent buried and concealed under the products of the third and latest period of eruption.

The materials ejected during the second period consist of lavas and the agglomerates, tuffs, and ashes derived from them—the accumulations of fragmentary matters generally greatly preponderating in quantity over the solid rocks; which latter, nevertheless, in consequence of their greater power of resisting denuding forces, often constitute all the most prominent and conspicuous parts of the islands.

Nearly the whole of the lavas of the second period belong to the trachytic class, but there appears to be a constant tendency in the later formed of them to approximate towards the rocks of the basaltic type. This gradual change in the character of the lavas is well exemplified in the series of successive cones and craters so well displayed in the southern part of the island of Vulcano. As an example of the composition of the lavas of this period, we may instance the rock constituting the central mass, and forming by far the larger part of Stromboli, which Abich found to possess a specific gravity of 2·7307, and a per-centage of silica of 61·78.

The lavas of the second period may be divided into three classes, examples of all of which may be found in each of the islands in which the products of this period are developed.

A.—The most abundant of these varieties are the ordinary trachytes, usually rendered of a highly porphyritic character, by the dissemination through their mass of scattered crystals of sanidine, but occasionally compact and granular in texture, and sometimes exhibiting banded and ribboned structures. These old trachytes are often found assuming red and purplish tints on weathering, and then exactly resemble in appearance, as they also do in chemical constitution, many of the "porphyrites" of ancient geological periods.

B.—A somewhat less common but very beautiful form assumed by these trachytes is that of a dark grey or almost black granular base, through which crystals of sanidine are diffused; by the passage of the granular or stony base into a more or less perfect vitreous condition, the rock assumes the well-known characters of a "pitchstone-porphyry." This rock—of which beautiful examples are found in the lava-streams issuing from the old ruined crater of Monte Sant' Angelo, constituting the highest point of Lipari, above Tivoli in the same island, and also near La Malfi in Salina—forcibly recalls to the mind the precisely similar varieties of rocks, so abundant at Beinn Shiant and the Scùr of Eigg in the Western Highlands of Scotland.

C.—The third variety of the Lipari trachytes finds its exact analogue in the celebrated Arso lava of Ischia, which has been so admirably described by Fuchs. Its base is similar to that of ordinary trachytes; but scattered through its mass in greater or less abundance occur crystals of augite, mica, and magnetite, with grains of olivine, which impart to the rock a more basic composition, and cause it to approximate towards the trachy-dolerites of Abich. Trachytes of this third class are found in Monte Rosa in Lipari, near Rinella in Salina, and in great abundance and variety in the southern part of Vulcano.

One of the most interesting features of the Lipari Islands is the series of wonderful changes which their rocks have undergone, in consequence of the passage through them, subsequently to their eruption, of acid gases and vapours. By this means the hard and crystalline trachytic lavas of Lipari have, over very large areas, been reduced to a soft, white, earthy material, to the eye exactly resembling chalk; in other cases they have assumed the carious and open crystalline texture of the "alaunstein" of German petrologists; while in others again they are found less altered, and presenting the most beautiful variegated tints. Similar changes may be seen taking place in the lava of Olibano, where it issues from the crater of the Solfatara of Naples, but in Lipari they are far more complete in character, and on a much grander scale.

The accumulations of fragmentary materials which constitute the larger portions of the mass of the Lipari Islands exhibit also many varieties of character. It is interesting to notice that, while we have no proof from included shells or other marine remains of any part of these tuffs having been accumulated under the sea, but, on the contrary, find the clearest evidence, in the leaves and stems of terrestrial plants which they so abundantly yield, that a part at least of them were accumulated under sub-aerial conditions, yet they almost always exhibit some signs of stratification, and not unfrequently, indeed, are very finely laminated. In explanation of this circumstance, however, it is only necessary to point to the materials, certainly of sub-aerial origin, which cover Pompeii, and to the ashes ejected from Vesuvius in 1872 and still enveloping its cone, both of which exhibit an unmistakably stratified or laminated character. The remembrance of these facts may serve to prevent us from too hastily inferring the sub-aqueous origin of volcanic tuffs occurring among ancient geological deposits, from their stratified appearance. Of beautiful examples of false-bedding, unconformable stratification, and similar appearances due to the action of local causes, innumerable interesting examples might be adduced from among the deposits of fragmentary volcanic materials in the Liparis.

In respect to their structure, these accumulations sometimes present the character of agglomerates made up of angular blocks, including some of vast dimensions, of all the varieties of lava before mentioned, mingled with volcanic bombs, scoriæ, lapilli, and ashes. At other times they are composed of materials of more uniform character and constitute tuffs; while not rarely they are made up of fine volcanic sand or dust and form beds of ash. These latter are usually of a chocolate brown colour, and often contain white specks, which are probably decomposed fragments of felspar crystals.

Near Bagno Secco, on the western side of the Island of Lipari, beds of rather fine-grained tuff or coarse ash are found, between the laminæ of which beautifully preserved leaves and stems of plants occur, in much the same manner as at Somma.

To the student of British geology the analogy presented by these modern leaf-bearing tuffs with those of Miocene age at Ballypalidy in Antrim, and at Ardtun in Mull, not only in the characters of their materials and in the state of preservation of the fossils, but in the particular groups of plants represented in them, such as planes, poplars, willows, flags, sedges, and horse-tails, is very striking. The best preserved examples of the beautiful fossil plants of Lipari were formerly obtained at an almost inaccessible point of the cliff near Passo della Scarpa; but the adventurous Liparote, who used to obtain them, having lost his life in one of his attempts to reach the spot, it is now rather difficult to obtain good specimens. Fragments of stems and leaves, however, abound at several points, and can be procured without difficulty by any moderately good climber.

The tuffs, etc., of the second period of volcanic activity in the Lipari Islands have suffered, equally with the lavas which accompany them, from being traversed by acid gases and vapours. The action of sulphurous acid on the lime of these volcanic rocks has given rise to the formation in them of beautiful veins of selenite, accompanied by Misy and other basic sulphates of iron, which are found intersecting them in all directions. As an illustration of one among the many difficulties, the like of which we may not unnaturally anticipate experiencing, when seeking to define the exact character of some volcanic products of former geological periods, I may mention that, in some cases the bands of finer-grained ash in Lipari are converted into an intensely hard rock of jaspery aspect, and with a conchoidal fracture, to which—but for its mode of occurrence, its gradation into the ordinary tuffs around, and the plant-remains which it not unfrequently contains—probably no geologist would dream of attributing its true mode of origin.

Of the lavas and tuffs of the second period of volcanic action in the Lipari Islands, a number of volcanic cones are built up, the craters of which, though usually clearly traceable, are often in the last stage of ruin and decay. Of these cones and craters we may instance the islands of Alicudi and Filicudi, each of which is a volcanic mountain rising directly out of the sea to the heights of 2,172 and 2,598 feet respectively, with vestiges of craters at their summits; in Salina we have the two similarly ruined volcanos of Monte Porri (2,850 feet) and Monte Salvatori (3,125 feet), the highest summit in the Lipari Islands; in the island of Lipari the lavas and tuffs we are now describing compose the Monte Sant' Angelo, the culminating point of the island, with its great axial crater and several smaller lateral ones on its eastern and western flanks; in Vulcano the period is represented by the series of ruined craters, forming all the southern parts of the island, and culminating in Monte Sarraceno (1,601 feet): and, lastly, the central cone of Stromboli, having an elevation of 3,090 feet, with the doubtful crater at its apex, and the much clearer one on its southern flank, also belongs to the same period.

In examining these old and much denuded craters, of which that on Monte Sant' Angelo (represented in Fig. 3) affords an excellent

FIG. 3.—Ruined Crater of Monte Sant' Angelo in Lipari, as seen from the summit of the Monte della Guardia in the same island.

example, the stratified arrangement of the tuffs, with converging dips in their interior parts and diverging ones exteriorly, a feature so characteristic of the structure of all volcanic cones (see Scrope's 'Volcanos,' 2nd ed. p. 60), is often very admirably displayed. The lava-streams can often be traced to their points of issue from the craters, but are sometimes cut up by denudation into isolated masses, capping hills composed of tuffs, like the plateaux of Ischia and the Auvergne. The lavas everywhere exhibit the characteristic slaggy or scoriaceous upper and under surfaces, and are often seen to rest on beds which are burnt to a bright red colour. The masses composed of soft tuffs are often furrowed by deep ravines, which render some parts of the islands almost impassable, but which, when accessible, afford the most beautiful illustrations of the structure of the volcanos.

But it is in the sea-cliffs of some of the islands, and more especially in those of the southern and older part of Vulcano, that we find the most instructive examples of that interlacing of agglomerates, lava-streams and dykes, which constitutes the characteristic architecture of volcanos. Not even the cliffs of Somma or the precipices of the Val del Bove can compare, in this respect, with the faces presented to the sea on the eastern, southern, and western sides of Vulcano, where the mountain has been deeply eaten into by the encroaching waves (see Fig. 4). For anything approaching in beauty and completeness to the wonderful sections here exhibited, we must go to the ruined and dissected volcanos of the Hebrides.

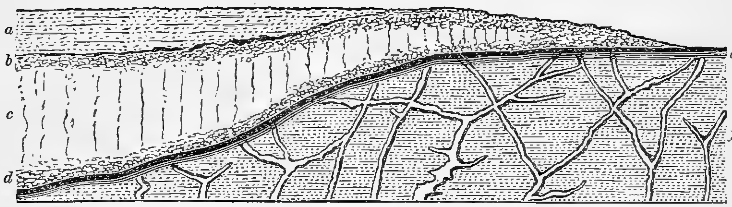


FIG. 4.—Section near Quaglia on the south-west coast of Vulcano.
a. Rudely stratified tuffs. *b.* Upper scoriaceous surface of lava stream. *c.* Compact central part of same. *d.* Scoriaceous under-surface of lava stream. *e.* Bed of burnt tuff of bright red colour. *f.* Tuffs traversed by many dykes.

That periods of great duration must have elapsed since the formation of the series of volcanic products which we have been describing, is indicated alike by the great amount of denudation which they have undergone and by the fact that they are covered by a younger series of deposits, some of which have themselves suffered not inconsiderably from the same cause. That, on the other hand, they are of no great antiquity, from a geological point of view, is shown by the fact that the vegetable remains imbedded in them all belong to well-known species of the Mediterranean area.

That movements of subsidence, similar in kind but less in degree than that which appears to have submerged the great central volcano of the group, must have taken place, in the case of the smaller and encircling cones, is shown by the relations which many of the lava-streams bear to them, as is particularly well seen in the coulées which form the peninsula of Monte Rosa, and which have evidently flowed from Monte Sant' Angelo. But that the movements which have taken place in them have not been uniformly those of depression, is also demonstrated by the existence around the shores of some of the islands of beautiful raised beaches, some of which are at least 100 feet above the sea-level. Of such raised beaches we have fine examples at the Rocca Piramida in Lipari and on the coast of Salina between La Malfa and La Capo (see Fig. 5).

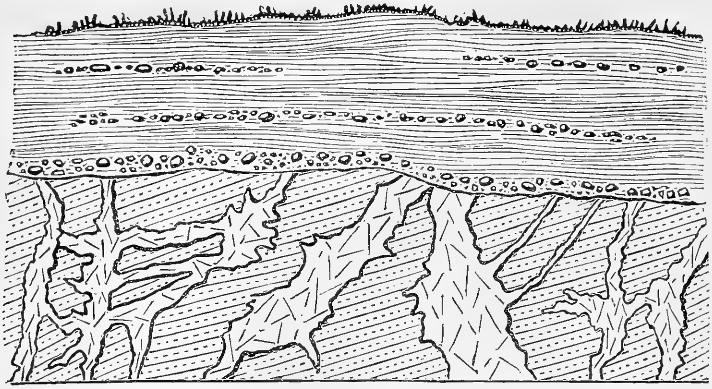


FIG. 5.—Interesting section at La Capo, the north-east point of Salino, exhibiting tuffs traversed by numerous dykes of lava and overlaid by stratified materials derived from them. (Raised-beach.)

We must postpone to a future communication the description of the remarkable linear arrangement of the volcanic vents of the Lipari Islands, when we hope also to give an account of some of the characteristics and products of the last series of igneous outbursts in the district.

(To be continued in our next Number.)

II.—A Chapter in the History of Meteorites.

By Walter Flight, D.Sc.,
Of the Department of Mineralogy, British Museum;
Assistant Examiner in Chemistry, University of London.

Introduction.

By the publication of *Die Chemische Natur der Meteoriten,* in 1870, Professor Rammelsberg accomplished the task which he had set himself, that of presenting to students of mineralogy a careful digest of the scattered contributions of the time to the literature of meteorites. Since that date no similar work of reference has been issued. Buchner's papers, intituled *Die Meteoriten in Sammlungen,* the first of which was issued at an earlier date than Rammelsberg's memoir, do not apparently continue to be published, the last one having appeared in Poggendorff's Annalen in 1869. It is from this period that I propose to take up the thread, and to give in the following pages a digest of all that has been published on the subject of meteorites since the beginning of that year. In this time many important contributions to this branch of mineralogical science have been made; highly interesting meteoric falls have taken place, among them it will here suffice to mention that of Hessle, in Sweden; remarkable cosmical masses have been discovered, of which none are more curious than the colossal meteoric irons of Ovifak, in Greenland; and the presence of new meteoric minerals determined, such as the calcium sulphide of the Busti aerolite and the rhombic form of silicic acid in the Breitenbach siderolite. The bearing of the study of meteorites on our knowledge of cosmical physics and geology will be readily acknowleged.

It is proposed to deal with the subject under the following four divisions :—

I. To present seriatim a description of all meteoric bodies that have been known to fall, or that may have been found, since the above date (1st January, 1869), including an account of all important phenomena attending their descent, and a description of their physical and chemical characters, or those of their ingredient minerals as far as they have yet been determined. In the examination of the analyses, it will be shown that the hypothetical silicate shepardite, which at the present time is supposed by many mineralogists and geologists[1] to form a constituent of meteorites (although it has never been isolated), not only need not be assumed to be present, but that the analytical results of these observers indicate the presence in the aerolite of such silicates only as have on some occasion or other been observed to occur as distinct species in a meteorite.

II. To produce a similar digest of work done from 1869—1874 on meteorites which had fallen, or had been found, at an earlier date, giving such results as correct earlier analyses.

III. To prepare an exhaustive notice of papers published from 1869—1874 on meteorites :

(1). In their relations to astronomical questions; their probable orbits; the phenomena attending their fall; their distribution on the earth's surface; spectroscopic examination, etc.

(2). In respect to better methods of analysis; new catalogues of collections; and the bibliography of this branch of mineralogy.

IV. To examine cases of doubtful falls, pseudo-aerolites, etc., which have been placed on record during the above interval.

Part I.

1869, January 1st, 12h. 20m. p.m.—Hessle, near Upsala.[2]

This is the first meteoric fall recorded to have taken place in Sweden. The sky was cloudy, and, though apparently unobserved at Hessle, a luminous meteor was noticed by observers at a distance. The noise accompanying the fall resembled heavy peals of thunder, followed by a rattling noise as of waggons at a gallop, and ending first with a note like an organ tone, and then a hissing sound. The stones were strewn over a line of country lying 30° E. of S. towards 30° W. of N. Some of them fell within a few yards of a number of

[1] In his address "Ueber die Entwickelung der Geologie in den letzten 50 Jahren," delivered before the German Naturalists' Association at Leipzig in 1872, Von Dechen alluded to shepardite (anderthalbfach kieselsaure Magnesia) as a characteristic meteoric mineral.

[2] O. Fahnehjelm. Meteorfallet i Fittja socken af Upsala län d. 1 Januari, 1869, *Oefversigt Vet. Akad. Förd.* 1869, No. 1, 59.—A. E. Nordenskjöld. *Kongl. Svenska. Vetensk. Akad. Handl.* viii. No. 9; *Pogg. Ann.* cxxi., 205.—G. Lindström. Kemisk Undersokning af Meteorstenarne från Hessle. *Kongl. Svenska Vetensk. Akad. Förd.*, 1869, No. 8.—K. A. Fredholm. Om Meteorstensfallet vid Hessle. Leipzig: Fritsch.—G. A. Daubrée. *Compt. rend.*, lxviii., 363.

peasants who were coming out of church; one struck the ice close to a man who was fishing on the Mälar Lårsta-Viken, and after digging a hole three or four inches deep, rebounded; when picked up, it was still warm.

The stones vary greatly in weight, from 2lbs. to 0·17 gramme (about 2½ grains). The smallest have the same structure and thickness of crust as the largest, and are in fact little complete meteorites. Such diminutive stones have not hitherto been noticed, and should be sought for at future aerolitic falls.

The exterior of the stones is black; the interior bright grey, and sufficiently porous to cling to the tongue. Though the structure of these meteorites is so loose that they break in pieces when thrown with the hand against the floor or frozen ground, it is a remarkable fact that nearly all the specimens which have been collected fell intact, and some of the heavier stones which struck the ice of the Lårsta-Viken failed to penetrate it, although the thickness was only a few inches on New Year's Day. This explains in some degree the statements of eye-witnesses as to their remarkably small downward velocity.

In appearance they resemble very closely the meteorites of Aussun and Clarac, Haute Garonne (9th December, 1858). They have been examined by Nordenskjöld, who so arranges the results of his analyses that he finds them to be composed of: 20 per cent. nickel-iron (chamoisite, Fe_8Ni), with some schreibersite and rather less than one per cent. of chromite; a variable amount of troilite (iron monosulphide); a trace of carbon, probably in the form of a hydrocarbon; 10 per cent. of labradorite; 37 per cent. of olivine; and 23 per cent. of 'shepardite.'

Two great difficulties, however, are presented by this explanation of the constitution of the Hessle meteorites. It is not only assumed that a basic silicate, like olivine, and a sesquisilicate, or acid silicate, like 'shepardite,' exist in intimate association in the same rock-mass, but it necessitates the retention as a mineral species of this very 'shepardite' which the researches of Dr. L. Smith on the Bishopville stone have shown to be no other than a pure magnesian enstatite (MgO,SiO_2).

In the following table are given: under I. the oxygen ratios of the mean of the total constituents from three analyses, after the nickel-iron had been removed by mercury chloride in one case, and by the magnet in another; under II. the oxygen ratios of acid and bases of silicate broken up by acid; and under III. the difference between I. and II., or the oxygen ratios of acid and bases of silicate unaffected by acid.

	I. Total.	II. Soluble.		III. Insoluble.	
Silicic acid	26·45	10·78		15·67	
Iron protoxide	2·971	1·858	9·976	1·113	7·352
Magnesia	11·82	7·559		4·261	
Lime	0·748	0·219		0·529	
Alumina	1·431	0·03		1·401	
Soda	0·358	0·31		0·048	

In the soluble part the oxygen ratios do not widely differ from those of an olivine, while the atomic ratio of iron oxide to magnesia, nearly 1 to 4, is that observed in many meteoric olivines; among others those of the aerolites of Chantonnay, Oesel, and Richmond. As in Nordenskjöld's analysis the soluble portion was collected after the powdered mineral had been digested for a long time with warm concentrated acid, it is certain that some portion of any bronzite or enstatite that might be present would undergo decomposition, and this would explain the slight excess over 1 to 1 in the oxygen ratios of acid and total bases in the insoluble part. This insoluble portion, it will be seen, appears to be chiefly bronzite, and here again the ratio of the two metallic oxides, also about 1 to 4, is that of the bronzite of several meteorites, including among them the three mentioned above; and the Hessle meteorite is a fourth example, in both the olivine and bronzite of which the atomic ratio of iron oxide to magnesia is the same (1 : 4). The alumina has been regarded as a constituent of the bronzite, very few specimens of that mineral, whether terrestrial or meteoric, containing none of this oxide; it could not be present as anorthite, as the chief amount is in the insoluble portion; nor could it be in the form of any other felspar, as the requisite alkali is not present.

The most remarkable feature of the Hessle shower is the association with the stones already described of other cosmical matter, chiefly composed of carbon. It was remarked by the peasants that some of the stones which fell on the ice near Arnö soon crumbled to a blackish-brown powder, which formed with the snow-water a mixture resembling coffee-grounds. Similar powder was found on the ice at Hafslaviken in masses as large as the hand, which floated like foam on water, and could not be held between the fingers. A small amount, secured for examination, was observed under the microscope to be composed of small spherical granules. It contained metallic particles extractible with the magnet, and, when ignited, burnt away, leaving a reddish-brown ash; heated in a tube, it gave a small amount of a brown liquid distillate. A specimen dried at 110° had the following composition :—

		Equivalent Ratios.
Carbon	51·6	8·6
Hydrogen	3·8	3·8
Oxygen (calculated)	15·7	1·96
Silicic acid	16·7	
Iron protoxide	8·4	
Magnesia	1·5	
Lime	0·8	
Soda, with trace of lithia	1·5	
	100·0	

The combustible constituent accompanying the stony matter in the above mixture appears to have the formula $nC_9H_4O_2$. The Hessle stones form a new member of the small class of carbonaceous meteorites, that is to say, such as contain carbon in the amorphous form, or combined with hydrogen and oxygen, or in both these conditions; it includes at present those which fell at Kaba, Cold Bokkeveldt, Alais, Orgueil, Goalpara, and others.

It was noticed that the stones found in the same district with the carbonaceous mass were, as a rule, quite round, and covered on all sides with a black, dull, and often sponge-like, crust. The iron particles on the surface of the smaller stones were usually quite bright and unoxidized, as would be the case if the stone had been heated in a reducing atmosphere. Nordenskjöld believes that the carbon compound frequently, perhaps always, occurs in association with meteorites, and he attributes its preservation at Hessle to the fact of the stones having fallen on snow-covered ground.—The paper is illustrated by a map of the district, indicating the exact points where the larger masses descended.

1869, May 5th, 6.32 p.m.—Krähenberg, near Zweibrücken, Rhenish Bavaria.[1]

A single stone was seen to fall, the sky being clear and bright. The noise of the explosion is described as having been louder than that of a cannon; this was followed by one resembling a roll of musketry, terminating with a sound as of the rushing of steam from a locomotive; the tone of the last sound increased in pitch, and abruptly ended with another loud noise. Although no luminous phenomena were observed at Krähenberg, a meteor was seen at Bingen, Speyer, Neuweiler, in Alsace, and in other parts, which observers agree in describing as emitting an intensely white light; one witness, who saw it in the zenith, states that the light was bluish. The inclination of the path of the meteor to the horizon is computed to have been 32°. From observations, made independently by two witnesses, it appears that this meteor came from the point in the heavens, 82° North Polar Distance and 190° Right Ascension. In the *Atlas of Meteors* (British Association) there is given a radiant point (85° N.P.D. and 189° R.A.) for the epoch of 2nd April to 4th May, and which is indicated as one of those that are "well-defined." It appears, then, to be highly probable that the Krähenberg meteorite, while traversing its cosmical path, belonged to the meteor shower, the radiant point of which lies near δ *Virginis*.

Vom Rath states that the stone fell from a small cloud. A little girl was within a few paces of the spot where it struck the earth, on the slope of a hill facing the S.E.; it entered the ground to a depth of from three to four feet, making a perfectly vertical hole. It was soon dug out, and when brought to the village was warm, but not hot.

The stone is of the form of a flattened spheroid, and weighed, when entire, about 33lbs. The crust is about 0·5 mm. thick, and though in most parts black, some portions possess the peculiarly reddish-brown colour noticed on the Pultusk stones. The specific gravity of the stone, free from crust, is 3·497; that of the crust is

[1] O. Buchner. *Pogg. Ann.*, cxxxvii, 176.—G. vom Rath. *Pogg. Ann.*, cxxxvii., 328.—C. E. Weiss. *Pogg. Ann.*, cxxxvii., 617.—G. Neumayer. *Sitzber. Wien. Akad.*, lx., 229.—P. Reinsch. Lithographic "*Suite Mikroscopischer Praeparate*" of this Meteorite, issued March, 1872; and *Tageblatt 45, Versammlung der Naturforscher in Leipzig*, 1872, 132.

3·449; as in the Pultusk meteorite, the crust is lighter than the body of the stone. A remarkable feature of the surface are the numerous furrow-like depressions, some 8 mm. deep, which often anastomose and radiate from the more even crown of the stone towards its periphery; they are confined to the more rounded side of the stone. A newly broken surface is light grey, and exhibits a net-work of fine black lines and veins of nickeliferous iron; in one place a little gangue of metal measured 3 inches in length and 0·3 to 0·5 mm. wide. This meteorite bears a great resemblance, both as regards the crust and internal structure, to those above alluded to, which fell at Pultusk, in Poland, on 30th January, 1868. Spherules are abundant; and other minerals readily distinguishable are: olivine, magnetic pyrites, and chromite; the whole being inclosed in a "sphaerolithic" ground-mass of white and grey grains.

Nickel-iron, containing 15·3 per cent. of nickel, constitutes 3·5 per cent. of the stone, a less quantity than is found in the Pultusk meteorites; magnetic pyrites amounting to 5·52 per cent., a larger proportion than is met with in the Pultusk stones, occurs in grains, some 1 to 2 mm. wide. The dark-coloured spherules, the presence of which is a characteristic of chondritic meteorites, are more distinct and numerous than those of the Pultusk stone: some are 2 mm. wide, and are easily removed from the ground-mass. Yellowish-white grains, some 1 mm. wide, are abundant, and here and there are found grains of chromite, bearing octahedral faces.

Viewed in the microscope, the mass of the stone is made up of numberless small white crystalline granules, which give colour in polarized light; they are stated by Vom Rath to be unacted upon by acid, and to consist essentially of a magnesium silicate, richer in silica than olivine. Among other curious constituents detected by the microscope are: a very small purple-red crystal bearing faces; a number of bright-yellow granules in distinct crystals; some light-yellow long prism-like forms; and a few large granules 0·5 mm. across, of a translucent red mineral, exhibiting conchoidal fracture. So small a portion of the stone could be devoted to chemical examination that none of these substances, nor even the large spherules, could be separately analyzed. The analysis of the stone furnished, after the nickel-iron and magnetic pyrites have been deducted, the per-centage numbers of acid and bases, the oxygen ratios of which are 1 : 1·448, the ratio in the Pultusk stone being 1 : 1·507. The analogy in composition, in respect of each constituent, of two bodies from so widely separated regions of planetary space is very striking. Vom Rath expresses his belief that "the siliceous portion of this meteorite, and indeed of the Pultusk stone, is mainly composed of olivine and another, a magnesium, silicate richer in silicic acid; but whether it be enstatite or shepardite ($2MgO,3SiO_2$), or whether both silicates accompany the olivine, cannot, unfortunately, be determined."

Apart, however, from the doubts that are now entertained respecting the existence of the magnesium sesquisilicate of Rose as a mineral species, the analytical determinations of Vom Rath will not be found, on examination, to support the theory in question. In addition to the composition of the entire stone, which is to be found below (I.), he gives in his paper the amounts of each of the bases dissolved in acid during a sulphur determination (see II.).

	I. Total Silicates.	II. Bases dissolved	Oxygen.		III. Bases undissolved	Oxygen.	
Silicic acid ...	46·37						
Magnesia ...	27·13	11·7	4·68	9·55	15·43	6·17	6·92
Lime	2·15	0·56	0·16		1·59	0·45	
Iron protoxide...	22·56	21·2	4·71		1·36	0·30	
Alumina... ...	0·67	0·14			0·53		
Loss (Soda?)...	1·12						
	100·00						

Assuming the bases dissolved to be those of an olivine, they would require 17·90 per cent. of silicic acid to form 51·36 per cent. of an olivine of the form FeO, MgO, SiO_2 (like that occurring in the meteorites of Chateau-Renard and Kakova), while the undissolved bases with 25·95 per cent. of silicic acid form 45·45 per cent. of a nearly pure magnesian enstatite. There now remain only 2·52 per cent. of silica, which, with the alumina, and what may possibly be potash, give oxygen ratios, pointing, with more accuracy than might be expected in so small a residue, to about 4 per cent. of what may be a felspar. This method of regarding the constitution of the meteorites of Krähenberg and Pultusk has the advantage of assuming the existence in these stones of such meteoric minerals only as have been isolated and clearly identified.—In an elaborate paper on the lithology of this meteorite, Weiss states that he detected the presence of three silicates, and by a careful study of a fresh surface of the stone, he finds that the grey silicate, which is probably enstatite, occurs in three distinct forms. This is a point of considerable interest, not only as tending to confirm the above calculations, but from the fact that three varieties of a nearly pure magnesian enstatite likewise occur in the Busti aerolite.

Reinsch has prepared eighteen microscopic slides of this meteorite, and made very effective pen-and-ink sketches of the more important of them. One shows a remarkable eroded spherule of iron; the evenly serrated surface is inclosed in a metallic shell, or rather net, so regular are the intervals at which this covering is broken through. Another exhibits spherules traversed by little dykes or veins of a mineral, which in one case is of a purple colour. Others show a beautiful blue mineral, which he suggests may be haüyne. He directs attention to the presence of magnetic pyrites and nickel-iron in the crust of the meteorite, and contends that, as these minerals would undergo change if exposed in air to a temperature at which the silicates forming the crust fuse, the meteorite must have been covered with a crust before it entered our atmosphere, and he ascribes the fusion to electrical agency, as seen in the perforated rocks (fulgurites?) of the Lesser Ararat, described by Abich.

1869, May 20th, 11.20 p.m.—Moriches, Long Island, Suffolk Co., New York.[1]

An unusually brilliant meteor was seen at New Haven, New York, Philadelphia, Hartford, and many other places. It appears to have moved, nearly horizontally, at an elevation of fifty miles, along a visible path of about 200 miles, and to have exploded over the Atlantic somewhat N. and E. of Boston. The time of flight is estimated at five seconds, which indicates a velocity of forty miles per second. Three minutes after the passage of the meteor, "a terrific sound" was heard at Moriches, which shook the house of the observer to the very foundation. The angular diameter of the meteoric body is estimated to have been 30′, the distance from Moriches at the time of the explosion, thirty-nine or forty miles, the altitude twenty-eight miles, and the actual diameter 1843 feet. It recalls to mind the celebrated meteor of 1783, August 18th, 9·30 p.m., which traversed Europe from N.W. to S.E.[2]

1869, May 22nd, 10.5 p.m. Paris time (9.45 p.m. Vannes time).—Kernouve, 2 kilometres from Cléguérec, Arrondissement de Napoléonville, Morbihan, France.[3]

A meteor was seen moving in the direction from S. to N. It burst very soon, throwing off a number of greenish-white sparks, which almost immediately lost their brilliancy, and in two and a half or three minutes an explosion was heard. At Vannes, the very intense bluish-white light, which lasted for some seconds, resembled that of burning magnesium. The stone penetrated the soil of a meadow to the depth of one metre, and was quite covered by the loose earth thrown up by the shock; when exhumed it was broken up by the peasants. A young girl, distant only a few metres, was the sole witness of the fall; the leaves and ends of the branches of some trees close at hand bore marks of having been scorched. The stone, when perfect, probably weighed about 80 kilogrammes, and was of a conical form; the crust is of two kinds: an outer black enamel rugose and blistered, and an inner simple coat of glaze; in some places grains of iron projected through both crusts. The interior is a dark grey colour, and is very compact and granular. The iron is disseminated in very brilliant grains; here in veins some centimetres long, there in masses several millimetres in diameter. The magnetic pyrites (troilite?) occurs but rarely in veins, sometimes in masses 3 centim. long, and 2 millim. broad. Occasionally grains of an enstatite or felspar are seen. In texture this stone bears a great

[1] E Loomis. *Amer. Jour. Sc.*, 1869, xlviii. 145.

[2] May 20th–22nd, appears at the present time to be a period during which meteoric falls may be looked for. During the last six years the following five falls have occurred:

1868, May 22nd,	Slavetic, Croatia.
1869, May 20th,	Moriches, New York.
1869, May 22nd,	Cléguérec, France.
1871, May 21st,	Searsmont, Maine.
1874, May 20th,	Virba, Turkey.

[3] De Limur. *Compt. rend.*, lxviii. 1338.—F. Pisani. *Compt. rend.*, lxviii. 1489.

resemblance to the aerolites of Pultusk (30th January, 1868). The density of the meteorite is 3·747; it gelatinizes with acid, giving off hydrogen-sulphide. Pisani states that the iron sulphide is not attracted by the magnet; he has, however, given it in the form of magnetic pyrites in the following total composition of the stone:

Nickel-iron	20·50
Magnetic pyrites (?)	5·45
Dissolved silicate	34·60
Undissolved silicate	40·22
	100·77

The nickel-iron is composed of:

Iron = 92·44 Nickel = 7·56 = 100·00

and the silicates of:

	SiO_2	Al_2O_3	FeO	MgO	CaO	Na_2O	
A. *Soluble* ...	29·04	2·98	22·31	42·95	1·36	1·36	= 100·00
B. *Insoluble* ...	56·94	5·37	9·89	21·93	3·53	2·34	= 100·00

1869, September 19th, 9 p.m.—Tjabé, near Pandangan, Bodgo-Négoro, in Residence Rembang, Java.[1]

A meteor, the brilliancy of which is stated to have surpassed that of the moon, was seen about nine in the evening to move in a north-easterly direction over the village of Tjabé. It was observed at Pandangan, the chief place of the district, as well as at Bodgo-Négoro, chief town of the division, lying east of Pandangan. At the same time a meteorite fell at Tjabé, at a distance of about twenty metres from the house of a native named Sokromo. The sound following the appearance of the meteor is described as an explosion, as loud as that of a cannon, followed by a noise resembling that caused by a carriage crossing a bridge; this lasted some time. The villagers sought in vain for the spot where the meteorite fell; at six o'clock next morning, however, it was found at the place already mentioned, at a depth of two feet in soil which had been hardened with a long drought. According to the report drawn up by the President of Rembang, it was remarked by the villagers that the aerolite, when found, was still so hot that it could not be touched with the hand. This statement, however, must be received with caution.

This stone, the only one found, weighed about 20 kilogrammes. It is covered with a dull greyish black crust, 0·5 mm. in thickness; the fresh fracture is dark grey, and exhibits a number of brilliant points: here and there brilliant plates 1 mm. square are met with, as well as a small number of very dark, almost black, grains of spherical form, with a diameter of about 2 mm. The mass of the stone is coarsely granular, and is so very hard that portions are only detached with a hammer with great difficulty.

The specific gravity of the metallic portion is 6·8; the magnet removed 14 per cent. constituents, which consist of two alloys of nickel-iron, containing respectively 6·2 and 12·5 per cent. of nickel; in one portion of the stone was found 6·17 per cent. of troilite. The density of the stone is 3·695.

[1] E. H. von Baumhauer. *Archives Néerlandaises*, vi. No. 4 (1871).—G. A. Daubrée. *Compt. rend.*, 1871, 16th December.

The analyses of the rocky portion yielded the following results :—

	SiO_2.	Al_2O_3.	FeO.	MnO.	MgO.	CaO.	Na_2O.	K_2O.	Chromite.
A. *Soluble* ...	34·72	0·70	26·14	0·65	35·70	1·61	0·48	Trace	— =100·00
B. *Insoluble*...	60·83	4·74	12·92	0·60	14·14	3·30	1·53	0·82	1·12=100·00

The soluble siliceous portion, forming 45·94 per cent. of the non-metallic part of the aerolite, consists of an olivine in which the oxygen ratios of FeO and MgO are as 2 : 5. As in most analyses of meteorites, where the separation of the silicate of the form $2RO,SiO_2$ is attempted to be effected by means of acid, the silica in A, the soluble portion, is insufficient to form an olivine. The silica of B, the insoluble portion, on the other hand, is not only present in ample quantity, to make good what is wanting in A, and to supply the silicates of the form RO,SiO_2, but is in sufficient excess to lead Baumhauer to assume the presence of a bisilicate in the insoluble portion. If, however, the requisite amounts of silica be apportioned to the protoxides of iron, manganese, magnesium, and calcium of A and B, to form the respective silicates, there remain in the insoluble portion the following constituents, the oxygen ratios of which, as will be seen below, do not differ widely from those of an albite or orthoclase :

$$SiO_2=5·326\ ;\ Al_2O=1·13\ ;\ K_2O=0·16\ ;\ Na_2O=0·39.$$

Baumhauer traces a resemblance, in point of composition, between the aerolites of Tjabé and Mezö-Madaraz (4th September, 1852), by comparing his results with those published by Atkinson,[1] who analysed the latter stone in Wöhler's laboratory. About the time of the publication of this paper of Baumhauer's (1871), Rammelsberg[2] announced the result (see infra) of his examination of the Mezö-Madaraz stone, which differs very considerably from those arrived at in the earlier analysis ; where, in the insoluble portion of the Mezö-Madaraz stone, Atkinson found no iron protoxide, Rammelsberg finds 13·27 per cent. It will suffice in this place to mention that the later analysis of the Transylvanian aerolite does not indicate the presence of an excess of silica, and yields numbers which point to the presence of an olivine, like that found in the meteorites of Hainholz (1856) and Shergotty (25th August, 1865), and of bronzite resembling that occurring in the aerolite of Chantonnay (5th August, 1812).

1869, October 6th, 11.40–45 a.m.—Stewart County, Georgia.[3]

When this stone fell, the sky was somewhat hazy, but there was no cloud. An observer at Bladen's Creek heard a roaring rushing sound in a north-westerly direction ; in a moment it appeared to be directly westward ; then a loud explosion, followed by six other reports, occurred. After these explosions a peculiar whizzing sound was heard, produced apparently by some large irregular body moving rapidly away, while a smaller one passed to the south-west with such a noise as is caused by a flying fragment of a shell.

[1] E. Atkinson. *Jour. Prakt. Chem.*, 1856, 357. *Phil. Mag.* xi. 141.
[2] C. Rammelsberg. *Zeit. Deutsch. Geol. Gesellsch.*, 1871, 734.
[3] J. E. Willet and J. L. Smith. *Amer. Jour. Sc.* l. 335, and 339.

This piece, it was found, descended about two miles and a half from the point where the explosion occurred; it weighs about $12\frac{1}{2}$ ounces. Two men, who were looking in the direction of the explosions at the time they took place, state that they saw a quantity of vapour much like a volume of steam escaping from an engine-pipe, which was violently agitated, and increased in bulk after each report, but disappeared soon after the last of them. Some labourers close at hand saw directly after the explosions something like a thin cloud cast its shadow over the field in which they were. The stone, already alluded to, and which was seen to strike the ground by two negroes who happened to be at work about twenty paces distant, appears to have come from the north-west, at an angle of about 30° with the horizon; it passed to a depth of ten inches into the soil. It has an irregular, seven-sided form, the longest side being about $2\frac{3}{4}$ inches long, and is covered with a black crust. The specific gravity is 3·65. The explosion appears to have been heard over a region about 30 miles N.E. and S.W. and 50 or 60 miles N.W. and S.E.

The fractured surface has a greyish aspect, and exhibits numerous greenish spherules, with white granular interstitial matter, and occasional particles of nickel-iron, troilite, or chromite. The nodules are sometimes more than 3 mm. in diameter, with an imperfect fibrous crystalline structure, the radiation usually commencing from one side of the spherule; they are more or less opaque, and of a dull, bottle-green colour, with a hardness of about 6. Analysis of this selected mineral gave the following results:—

		Oxygen	Ratios.
Silicic acid ...	48·62 ...	29·9	29·69
Alumina ...	8·05 ...	3·79	
Iron protoxide	11·21 ...	2·51	14·31
Magnesia ...	30·18 ...	11·80	
	98·06		

The formula of this mineral, with a portion of the silica replaced by alumina, a not unfrequent occurrence in minerals like hornblende, hypersthene, etc., is therefore RO,SiO_2 and it is probably a bronzite. The nickel-iron has the composition:

Iron = 86·92; Nickel = 12·01; Cobalt = 0·75 = 100

and that of the rocky portion is as follows:

	SiO_2.	Al_2O_3.	FeO.	MgO.	CaO.	Na_2O.	
A. *Soluble*	41·08	0·32	18·45	41·06	—	—	=100·91
B. *Insoluble*	56·03	5·89	15·21	21·01	0·10	2·97	=101·21

The author deduces the following for the composition of the stone:

Nickel-iron	7·0
Magnetic pyrites	6·1
Bronzite, olivine, albite, or oligoclase, and chromite	86·9
	100·0

1869, November 6th, 7 p.m.—Fawley, near Southampton.[1]

The correspondent observed two meteors within a few minutes of seven o'clock on the evening of that day, which was a Saturday, and

[1] A. T. Smith. *The Standard*, November, 1869.

on the following Wednesday discovered a 'meteorite' which weighed more than 1 lb. avoirdupois. "It had not penetrated the ground more than half an inch." From the description of what he found, it appears that he picked up a nodule of marcasite, which had probably been left exposed on the surface after heavy rain had washed away the surrounding soil.

1869, December 25th.—Murzuk, Fezzan [Lat. 26° N.; Long. 12 E. of Paris].[1]

The letter of M. Coumbray, communicated to the Geological Society by Mr. R. H. Scott, announced the fall of an aerolite, or bolide, at Murzuk, in the presence of a group of Arabs. The bolide on falling is described as having "exploded with a sound resembling pistol shots and a strong odour." The intelligence was communicated to the Vienna Academy by Haidinger, and to the Berlin Academy by Dove; and Mr. Greg, in the British Association Report, states that it fell on the 26th December, and that it weighed 6000 lbs.

It appears highly probable, however, from a statement laid before the Berlin Academy by G. Rose[2] at a more recent date, that no meteoric fall took place. According to letters received from the Austrian Consul at Tripoli and Hag Ibraim Ben Alua, Shiek of Murzuk, a corporal, who was on guard at the gate of the town on the night of the 25th, heard a series of explosions, like the discharge of nine muskets. Hearing the alarm, the officer collected five men, and, sallying forth, they met a man, who stated that the noise was not the report of guns, but the explosion of a meteor, which burst in the direction of a little village called Namus. The writers of the letters were of opinion that no meteorite had been found.

Meteoric Iron. Found in 1869 or 1870.—Shingle Springs, Eldorado County, California.[3]

This mass, said to be the first discovered in California, was rescued in 1871 from the forge of a smith, who found it in a field near Shingle Springs. It weighed about 85 lbs., and its largest dimensions were 24 and 29 c.m. It is very homogeneous, only two small masses of pyrites (troilite?) being visible on one of the sides. The crust to a depth of from 4 to 5 c.m. is remarkably hard. The density 7·875 (that of some pieces removed by the planing tool being 8·024) is above the average density of meteoric iron, and this is most probably due to the presence of an unusually large proportion, more than 17 per cent., of nickel, as the subjoined analysis indicates.

Iron	81·480	Carbon	0·071
Nickel	17·173	Silicium	0·032
Cobalt	0·604	Phosphorus	0·308
Aluminium	0·088	Sulphur	0·012
Chromium	0·020	Potassium	0·026
Magnesium	0·010		
Calcium	0·163		99·987

[1] M. Coumbray, *Jour. Geol. Soc.*, xxvi. 415. Geol. Mag., VII. 236.—R. P. Greg. *Rep. Brit. Assoc.* 1871.—*Bullet. Meteorologico*, ix. 4.—G. Rose. *Monatsber. Berlin Ak.*, November, 1870.—G. Tschermak. *Sitz. Wien. Ak.* June, 1870.

[2] G. Rose. *Monatsber. Berlin Ak.*, 1871, 804.

[3] B. Silliman. *Amer. Jour. Sc.* [3] vi. 18.

Another remarkable feature of this iron is the obscure characters of its crystalline structure: when etched, the acid discloses a confused granular surface, exhibiting under a lens a reticulated structure with numerous brilliant points and V-shaped lines. The Eldorado iron resembles that of the Cape of Good Hope, analyzed by Uricoechea, in the absence of Widmannstättian figures and in the presence of a large per-centage of nickel.

The meteoric irons which contain most nickel (and cobalt) are:

	Nickel.	Cobalt.	Total.
Grenville, Tenn.	17·10	2·04	19·14 per cent.
Tazewell Co., Tenn. ...	14·62—15·02	0·43—0·50	— ,,
Cape of Good Hope ...	15·09	2·56	17·65 ,,

Few analyses have detected more than 10 per cent. of nickel in an iron, and the average amount of this metal in eighty analyses compared by Silliman is not above 7·25 per cent.

This is not the earliest notice of the Eldorado iron. In June, 1872, Shepard[1] published a short note on it in the same journal. He determined the specific gravity to be 7·80, and found only 8·88 per cent. of nickel, as well as 3·5 per cent. "insoluble, consisting of a mixture of Fe_2O_3 and FeO, with minute silvery particles of supposed phosphor-metals." The examination was evidently an imperfect one.

Meteoric Irons found in 1869.—Staunton, Augusta Co., Virginia.[2]

This is the fourth recorded instance of meteorites having been found in the State of Virginia. Three masses of meteoric iron have recently been met with: No. 1, weighing 56 lbs., was turned up by a plough, five miles somewhat E. of N. from Staunton, in lat. 38° 14′ N., and long. 79° 1′ W.; No. 2 weighs 36 lbs., and was met with one mile S.E. of No. 1; and No. 3, which weighs $3\frac{1}{2}$ lbs., was found half a mile still further S.E.

They were covered with a dark brown crust $\frac{1}{8}$ to $\frac{1}{3}$ in. thick; on exposure to moist air, a liquid, containing iron, nickel, and chlorine, exuded from many parts of the surface. This iron, which exhibits feeble magnetic polarity, and has a specific gravity of 7·83 to 7·85, is compact and highly crystalline, and contains occasional grains of troilite. Traces of Widmannstättian figures can be detected even without acid; but this reagent developes them in great beauty, and with considerable resemblance to those of the Lenarto and certain Mexican specimens. The irons were cut so as to give different projections of the same crystalline structures; in No. 1 the bands of iron and schreibersite intersect at 120° and 60°, in No. 2 they approach 90°, and in No. 3 are at about 60°.

The author states that by prolonged action of acid, white, pliant, and strongly magnetic laminæ of schreibersite are brought to view. He does not appear to have analyzed them, and to judge from observations made on other irons, I consider it highly probable that the

[1] C. U. Shepard. *Amer. Jour. Sc.*, [3] iii. 438.

[2] J. W. Mallet. *Amer. Jour. Sc.*, [3] ii. 10; *Brit. Assoc. Report* (Brighton), 1872, 77; *Proc. Royal. Soc.* xx. 365; *Pogg. Ann.* cxlvii. 134.

plates are not schreibersite, which is very brittle, but an alloy free from phosphorus, and containing about one-third its weight of nickel. The three masses gave on analysis the following results:

	No. 1.	No. 2.	No. 3.
Iron	88·706	88·365	89·007
Nickel	10·163	10·242	9·964
Cobalt	0·396	0·428	0·387
Copper	0·003	0·004	0·003
Tin	0·002	0·002	0·003
Manganese	trace.	—	trace.
Carbon	0 172	0·185	0·122
Phosphorus	0·341	0·362	0·375
Sulphur	0·019	0·008	0·026
Silica	0·067	0·061	0·056
Chlorine	0·003	0·002	0·004
	99·872	99·659	99·947

The chlorine is not of meteoric origin; a solid piece of No. 1, weighing 50 grammes, and quite free from flaws or fissures, contained no chlorine whatever. Some portion of the siliceous residue from the action of the acid probably consists of silicide of iron; when magnified 500 diameters, and examined by polarized light, it is found to consist of an amorphous powder, and rounded transparent grains of 0·0025 to 0·0100 mm. diameter, and with well-marked doubly refracting characters.[1] The three masses are, beyond question, portions of a single fall.

Pieces of this iron have been forged. One, which was hammered cold, could be beaten into any desired shape; a second, which had been exposed to a red heat in vacuo, could only be forged in the cold with much difficulty; while a third piece that had been subjected to a white heat could not be forged at all, and crumbled under the hammer when reheated. Mallet is of opinion that the brittleness arose from the melting out of the phosphide, "leaving the iron porous." As the amount of phosphorus present was but small, and did not exceed one per cent., it may have rendered some portion of the iron, "cold short."

The gases occluded by this iron were collected by Mallet and analyzed. The material consisted of some turnings and a solid piece of the metal. The cutting apparatus employed to reduce them to the requisite size was heated to a red heat, and quenched in water, to remove all traces of oily matter. Graham extracted from the Lenarto iron 2·85 times its volume of gas; Mallet obtained 3·17 volumes from his specimen. The latter was heated during fourteen and a half hours at a red heat, and then to an incipient white heat. During the first two and a half hours 52 per cent. (I.) of the entire gas was removed; in the next 2 hours 20 minutes, 24 per cent.; (II.), and in the remaining nine and a half hours, 24 per cent. (III.). Below are given for comparison the composition of these three

[1] The residue left on treating the Tuczon iron with acid appears to have borne a great resemblance to this substance. Compare with the description given in Buchner's *Meteoriten*, p. 183.

quantities as well as that of the gas occluded in the Lenarto iron and that of manufactured iron:

	Virginia Iron.				Lenarto Iron.	Shoeing Nails.
	I.	II.	III.	Total.		
Hydrogen	22·12	10·52	3·19	35·83	85·68	35·0
Carbonic oxide	15·99	11·12	11·22	38·33	4·46	50·3
Carbonic acid	7·85	1·02	0·88	9·75	—	7·7
Nitrogen	6·06	1·45	8·58	16·09	9·86	7·0
	52·02	24·11	23·87	100·00	100·00	100·0

These results unfortunately do not admit of very exact comparison, as only a portion of the gas extracted from the Lenarto iron was quantitatively examined. Although the relative quantity of hydrogen in the Augusta iron is much less than in the Lenarto iron, it amounts to 1·4 times the volume of the iron, while manufactured iron under ordinary pressure takes up only 0·42 to 0·46 of its volume of this gas. Mallet's results have shown that Graham's view, that the predominance of carbonic oxide among the occluded gases is indicative of telluric origin, is no longer tenable. In connexion with these differences in composition of the gases constituents of meteorites, it is interesting to notice that the observations of Secchi and Huggins have shown that carbon plays an important part in certain cosmical regions, although the spectroscopic evidence in the case of this element is as yet less definite than it is in regard to hydrogen.

1869 (and 1871). Trenton, Washington Co., Wisconsin.[1]

An additional fragment of this meteorite, weighing 16½ lbs., was found in 1869; and another, weighing 35 lbs., was dug up in 1871. All the six fragments (143 lbs.) now collected were found in the same field.

(To be continued in our next Number.)

III.—Descriptions of New Species of *Cystiphyllum* from the Devonian Rocks of North America.

By H. Alleyne Nicholson, M.D., D.Sc., F.R.S.E.,
Professor of Biology in the College of Physical Science, Newcastle-on-Tyne.[2]

(PLATE I.)

No less than seven species of *Cystiphyllum* have already been recorded as occurring in the Devonian Rocks of North America; viz. *C. vesiculosum*, Goldf., *C. Senecaense*, Billings, *C. grande*, Billings, *C. sulcatum*, Billings, *C. Americanum*, Edw. and Haime. *C. aggregatum*, Billings, and *C. mundulum*, Hall. To these I have now to add the following four species, all of which have been obtained by me from the Devonian Formation of Canada and Ohio.

[1] J. L. Smith. *Mineralogy and Chemistry*, 348.—J. A. Lapham. *Am. Jour. Sc.*, [3] iii. 69.

[2] Read before the British Association, Section C., Belfast, 1874.

G. H. Ford Mintern Bros imp.

Species of Cystiphyllum. (Devonian.)

CYSTIPHYLLUM OHIOENSE, Nicholson. Pl. I. Figs. 2, 2*a*.

Spec. char.— Corallum small, turbinate, simple, sometimes twisted, but usually straight, or slightly curved. Length of corallum usually about six lines, varying from four to nine lines; the calice varying in diameter from four to six lines. Epitheca distinct, marked with longitudinal striæ, and usually showing well-marked annulations and constrictions of growth. No calicular gemmation, nor radiciform prolongations of the epitheca. Calice not oblique, very deep, generally occupying from one-third to two-thirds of the entire length of the corallum, not flattened below. The interior of the calice shows more or less distinct septal striæ, thirty or more in number. Vesicles of the interior small.

The dimensions of an average specimen are: length, eight lines; diameter of calice, six lines; depth of calice, four lines and a half.

This pretty little species is readily distinguished from all others previously described, although the specimens upon which it is founded are much silicified, and do not exhibit some points of structure as well as could be desired. The species is characterized by its uniformly small size, its deep, pointed, and not oblique calice, the presence of distinct septal striæ, and the absence of radiciform prolongations of the epitheca. It is most nearly allied to *C. mundulum*, Hall, from the Devonian of Rockford, Iowa (Twenty-third Annual Report on the State Cabinet, 1874), but is distinguished by its smaller size, the smaller number of its septa, and its much deeper and more pointed calice.

Locality and Formation.—Common in the Corniferous Limestone, Columbus, Ohio.

CYSTIPHYLLUM SQUAMOSUM, Nicholson. Plate I. Figs. 4, 4*a*, 4*b*.

Spec. char.— Corallum simple, turbinate, but extraordinarily flattened. Dorsal surface greatly expanded, nearly or quite flat; lateral margins straight, and forming an angle with the curved ventral surface, which is much reduced in size. Calice extraordinarily oblique, making an angle with the dorsal surface of not more than 10° or 12°, very shallow and widely open, its deepest point being situated at a point about one-third of the length above the base. Vesicles of the interior about one line in diameter. Owing to the fact that all the examples of this coral which have been examined are converted into orbicular silica, the characters of the septal striæ and epitheca cannot be determined. Some specimens exhibit the same form of calicular gemmation as is seen in *C. vesiculosum*,—that is to say, the coral continues growing for a certain period, and then sends up a fresh calice from the centre of the old one. In this species, however, the new calice, instead of being continued in the axis of the coral, is directed more or less nearly at right angles to the plane of the old calice.

The dimensions of the largest individual observed are as follows: Length, measured along the dorsal surface, twenty-four lines; length, measured along the ventral surface, seven lines; greatest thickness, seven lines; diameter of calice, twenty-one lines; greatest depth of calice, six lines. In the smallest individual observed the dimensions are: Length, measured along the dorsal surface, thirteen lines; length, along the ventral surface, four lines; greatest thickness, four lines; diameter of calice, ten lines; greatest depth of calice, two lines.

This wonderful species is readily distinguished by its extraordinarily flattened and scale-like form, due to the extreme obliquity and shallowness of the calice, the flattening of the dorsal surface, and the almost total disappearance of the lateral surfaces. No other species of the genus known to me even approaches *C. squamosum* in these characters, and these are, therefore, of themselves sufficient to characterize the species. All the specimens I have seen are covered with remarkably large and fine "Beekite-markings," and the more minute characters of the coral are thereby entirely obscured.

Locality and Formation.—Corniferous Limestone, Columbus, Ohio.

CYSTIPHYLLUM FRUTICOSUM, Nicholson. Plate I. Figs. 3, 3*a*.

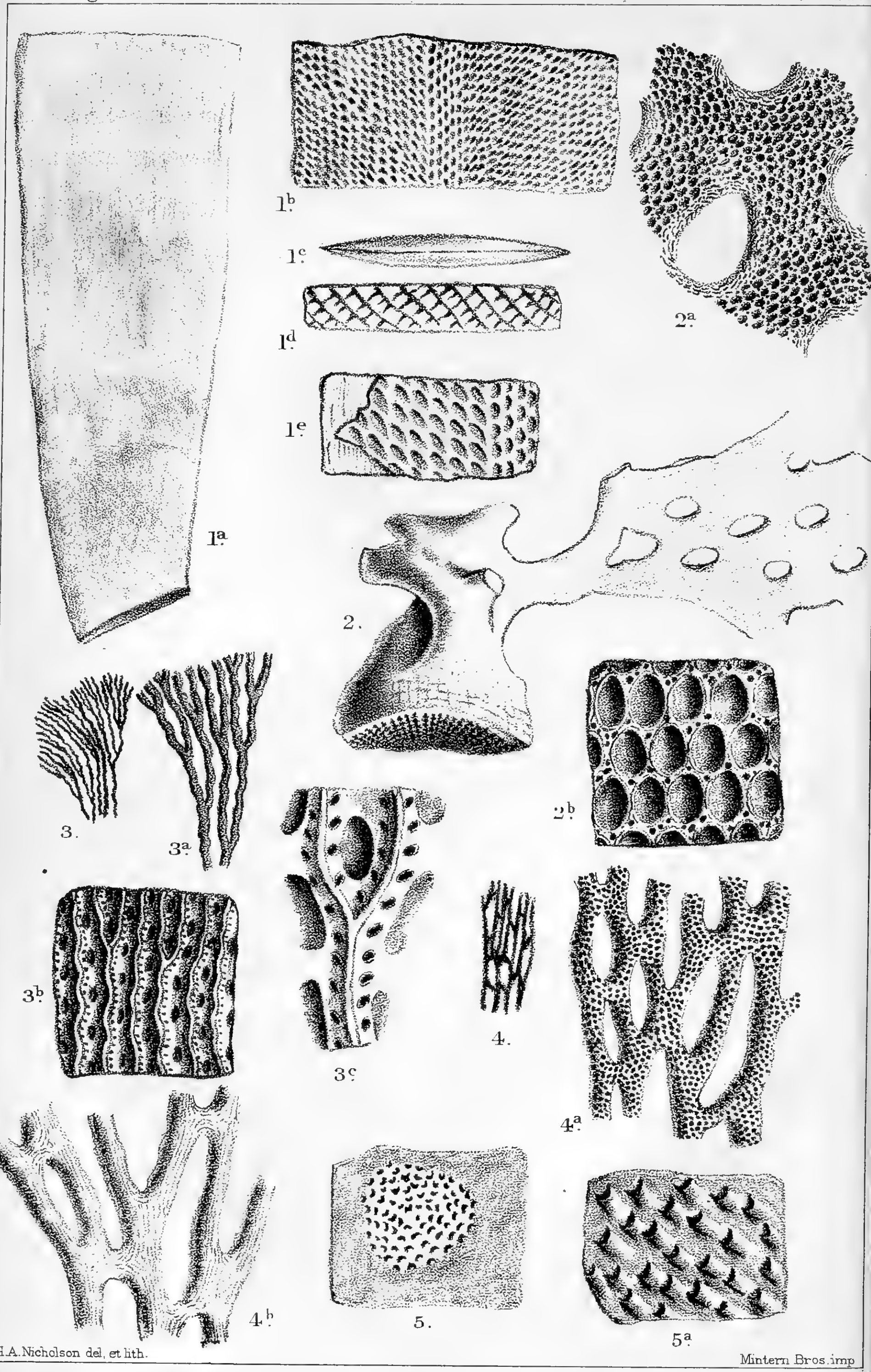
Spec. char.—Corallum aggregate, composed of numerous cylindrical, straight or slightly flexuous corallites, growing side by side, but not connected by epithecal processes or expansions, and often forming colonies of several feet in circumference. Corallites about three lines in diameter, or rather less, and placed usually at intervals apart of two lines, less or more. Epitheca thin but distinct, marked with very numerous fine encircling striæ and fainter vertical striæ, as well as with irregular annulations and constrictions of growth. Calice moderately excavated, from one and a half to two lines in depth, exhibiting numerous bullæ, sometimes with septal striæ near the margin. Internal structure wholly vesicular, the vesicles having a diameter of from half a line to nearly one line.

With the exception of the present very remarkable form, and the equally singular *C. aggregatum* of Billings, all the species of *Cystiphyllum* are simple. Its compound character is, therefore, of itself sufficient to distinguish *C. fruticosum* from all the hitherto recorded species of *Cystiphyllum* except *C. aggregatum*, and from this it is separated by its wholly different form and mode of growth. In its general appearance *C. fruticosum* presents the closest possible resemblance to *Diphyphyllum arundinaceum*, Billings, with which it not uncommonly occurs associated; but its internal structure separates it at once, and shows it to be a genuine *Cystiphyllum*.

Locality and Formation.—Not uncommon in the Corniferous Limestone of the Townships of Wainfleet and Walpole, Ontario.

CYSTIPHYLLUM SUPERBUM, Nicholson. Plate I. Fig. 1.

Corallum of large size, simple, turbinate, very broadly expanding. Calice extremely large, circular, moderately deep, and very oblique, making an angle of about 50° with the dorsal surface of the corallum, and one of about 150° with the ventral surface. The septa are marked by distinct rows of bullæ or vesicles, which radiate from the bottom of the cup, and are not less than one hundred and forty to one hundred and fifty in number. The vesicles are small, not exceeding half a line in diameter in the circumferential portion of the coral. Epitheca well developed, with numerous fine encircling



Devonian Polyzoa.

striæ and annulations of growth. Owing to the obliquity of the calice, the dorsal surface of the corallum is nearly twice as long as the opposite or ventral surface; and the greatest thickness is attained at a point situated about three inches above the base, or at about one-half of the total length. The only individual observed had the following dimensions: Length measured along the dorsal surface, six inches; along the ventral surface, three inches and a half. Greatest thickness, at three inches above the base, about three inches and a half. Diameter of calice, four inches and a half; depth of calice about one inch.

This fine species is most nearly allied to *C. vesiculosum*, Goldfuss; but it is distinguished from this and all other recorded species of the genus, by its comparatively gigantic dimensions, its very rapid expansion from the base upwards, and the striking obliquity of the calice. When viewed in profile (as in Pl. I. Fig. 1), its outline appears to be somewhat rhomboidal. This, however, is not a natural or essential appearance, but is due to the fact that the dorsal surface, in the individual examined, is abruptly geniculated at about the middle of its length. There is, however, no reason for supposing that this feature would prove to be a normal one in the species.

Locality and Formation.—Hamilton Group, Arkona, Township of Bosanquet, Ontario.

EXPLANATION OF PLATE I.

Fig. 1.—*Cystiphyllum superbum*, Nich., viewed in profile, of the natural size. The single dark line shows the outline of the calice as seen in a front view.

Fig. 2.—*Cystiphyllum Ohioense*, Nich., of the natural size. 2*a*. Calice of the same viewed from above, of the natural size.

Fig. 3.—Fragment of *Cystiphyllum fruticosum*, Nich., of the natural size. 3*a*. Calice of one of the corallites of the same, slightly enlarged.

Fig. 4.—*Cystiphyllum squamosum*, Nich., viewed from the front, of the natural size. 4*a*. Profile view of the same. 4*b*. Profile view of another individual of the same, in which a secondary calice has been produced at right angles to the primary calice. All these specimens are silicified, and are covered with "Beekite-markings."

IV.—Descriptions of New Species and of a New Genus of Polyzoa from the Palæozoic Rocks of North America.

By H. Alleyne Nicholson, M.D., D.Sc., F.R.S.E.,

Professor of Biology in the College of Physical Science, Newcastle-on-Tyne.

(PLATE II.)

Genus Heterodictya, Nicholson.

Polyzoary (?) forming a simple, flattened, unbranched, two-edged frond, with sub-parallel sides, consisting of two series of cells, the bases of which rest upon opposite sides of a thin longitudinally-striated central membrane or laminar axis, from which they pass obliquely outwards in opposite directions. The cells open in longitudinal rows on the two flat or slightly convex surfaces of the frond, and have the form of more or less cylindrical tubes, which are septate or are divided transversely by a series of well-developed tabulæ. In the only species known the cells of a few of the median rows of the frond are straight, but those of the lateral rows are oblique. Cell-mouths unknown.

In most essential characters, and in general appearance, the genus *Heterodictya* entirely resembles *Ptilodictya*. We have, however, the very anomalous and very important feature, that the cells in the present genus are as thoroughly and as regularly tabulate as the corallites of *Chaetetes* or *Favosites*. This clearly necessitates the removal of *Heterodictya* from *Ptilodictya*, and establishes a very interesting transitional link between the Polyzoa and the Tabulate Corals. I am only acquainted with a single, exceedingly large, species which can certainly be referred here. I should however, suspect that *Ptilodictya* (*Flustra*) *lanceolata*, Goldfuss, will very probably turn out to be an example of this genus.

Heterodictya gigantea, Nicholson. Plate II. Figs. 1*a*–1*e*.

Polyzoary forming a single, flattened, unbranched, two-edged frond, the dimensions of which are unknown, though certainly very great. The largest specimen observed expands gradually in width in proceeding from the base upwards. Its length is three and a quarter inches; the breadth of the broken base is nine lines, and the breadth of the broken distal extremity is fifteen lines. Both ends of this fragment are broken away, and its total length, when perfect, may be estimated with every probability as having been at least half a foot, with a width of not less than two inches. The edges of the frond are quite sharp, and its width in the centre is two lines or a little more. Its cross-section is thus acutely elliptical, the two poriferous surfaces being gently and regularly convex, without any central angulation. The frond is completely divided into two halves by a central laminar axis, which is marked with longitudinal striæ, conforming with the rows of cells, but does not exhibit arched transverse striæ. The cells are arranged in longitudinal rows, in three series. The first series is central, and consists of a few rows in which the successive cells are themselves longitudinal, and are not obliquely disposed. The remaining two series of rows are lateral, and each consists of a number of rows in which the cells are directed obliquely outwards and upwards as regards the margin of the frond in the direction of the row itself (Pl. II. Figs. 1*b* and 1*e*). The general arrangement of the cells is thus penniform. There are about six rows of cells in one line measured transversely, and thus there are about ninety rows altogether at the wider end of the frond. There are four or five cells in the space of one line measured longitudinally, and the cells are alternate or sub-alternate in contiguous rows. The cells have the form of cylindrical tubes directed upwards towards the surface at an angle of about 70° with the laminar axis. Each tube is partitioned off transversely by well-developed tabulæ, of which there are five or six in the space of one line, some of them not quite extending across the tube, but the most of them complete. The bases of the cells, as seen by decortication of the laminar axis, have mostly the form of narrow ovate slits. The free surfaces of the frond, and consequently the characters of the cell-mouths, are unknown.

This remarkable form resembles *Ptilodictya lanceolata,* Goldfuss, in its general shape, and in the penniform arrangement of its cells; and, as before remarked, it seems by no means impossible that the latter species may ultimately be shown to possess tabulate cells, and thus belong to the genus *Heterodictya.* Under any circumstances, however, *P. lanceolata* is separated from the present form by its comparatively diminutive dimensions; and I know of no other recorded species of the genus *Ptilodictya* with which *Heterodictya gigantea,* apart from its internal structure, could be confounded.

Locality and Formation.—Rare in the Carboniferous Limestone of Jarvis, Township of Walpole, Ontario. (The specimens from which the above description is taken were collected by Mr. George Jennings Hinde, F.G.S.)

PTILODICTYA COSCINIFORMIS, Nicholson. Plate II. Figs. 2–2*b*.

Polyzoary rooted by a strong footstalk, which is partly striated longitudinally, partly covered with the apertures of cells interspersed with numerous minute interstitial tubuli. At the summit of the footstalk the frond divides into a number of flattened branches, which ultimately divide and coalesce with one another, so as to form a network with oval meshes. The branches of this network are flattened and sharp-edged, with gently rounded surfaces. Their cross-section is acutely elliptical, their thickness in the middle being half a line, their width being two lines, and the meshes which separate them being about two lines in their long diameter. The sharp borders of the branches are marked with longitudinal and oblique striæ, interspersed with the apertures of minute tubuli, a complete marginal ring of this nature surrounding each mesh of the terminal network. The cells are not disposed in longitudinal rows separated by elevated lines, but are arranged quincuncially, so as to form two series of intersecting curved diagonals. The cell-mouths are regularly oval, each with a distinct rim, not elevated above the general surface, about six or seven of them occupying the space of one line measured diagonally. The interspaces left by the apposition of the oval cell-mouths are entirely filled by very minute interstitial tubuli, the apertures of which are circular or oval.

This beautiful species forms in many respects a transition between the typical *Ptilodictyæ* and the thin reticulated expansions to which the name of *Clathropora* or *Coscinium* has been applied. It is distinguished by the following more important characters: 1. The mode of growth is peculiar. The polyzoary springs from a strong and thick root or footstalk, from the top of which proceed several branches, which do not lie in the same plane, but are so disposed as to form a tuft or cluster similar to that of such a recent form as *Flustra truncata.* These branches sub-divide, and their divisions inosculate so as to form a network, the characters of which are quite similar to that of *Clathropora.* 2. The cells are not arranged in longitudinal rows separated by elevated lines. 3. The cell-mouths are oval, and are quincuncially disposed. 4. All the interstices between adjacent cells are filled up with numerous minute interstitial tubuli, similar tubules being present on the striated margins of the branches, and over considerable portions of the footstalk.

The only example of this species that I have seen is growing upon *Heliophyllum Halli*, to the exterior of which the footstalk is attached by a widely expanded base.

Locality and Formation.—Bartlett's Mills, Arkona, Township of Bosanquet, Ontario. In the Hamilton Formation.

FENESTELLA DAVIDSONI, Nicholson. Plate II. Figs. 3–3*b*.

Frond small, flabelliform, the branches ("interstices") keeled on both sides with very high, thin, and sharp-edged carinæ. Three or four branches in the space of one line, dividing dichotomously, usually with great regularity, at intervals of from two to three lines. Both the branches and the keels are more or less wavy or sinuous, sometimes as regularly so as in some *Reteporæ*; whilst the dissepiments are very wide, deeply sunk beneath the level of the celluliferous surface of the frond, and presenting the appearance of being formed by anastomosis of the branches. The dissepiments are fully one-third of a line in width, and do not carry cells. The fenestrules are oval, about one-third of a line in length, and slightly less than this in width; about two of them in the space of one line measured longitudinally, alternately placed in contiguous rows. The cell-mouths are rounded or transversely oval, about three of them opposite to each fenestrule. Non-poriferous side of the branches smooth, with the same thin, sharp, and prominent keel as exists on the celluliferous side.

This species, in its mode of growth and division, as well as in the sharpness of the carina between the rows of cells, strongly resembles *Fenestella Milleri*, Lonsdale; but the latter is stated to possess narrow and slender dissepiments, placed two lines apart, with fenestrules five or six times longer than wide, about twelve pores going to a fenestrule. The corresponding characters in our species are so strikingly different, that, in spite of the superficial resemblance, I feel fully justified in separating it from *F. Milleri*; and I have great pleasure in dedicating it to my friend Mr. Thomas Davidson, F.R.S.

F. Davidsoni is distinguished by its regularly dichotomising branches, with prominent sharp-edged keels on both sides; the undulated character of the branches; the deeply sunk position and great width of the dissepiments, which carry no cells, and look as if formed by anastomosis of the branches; and the oval, slightly longer than wide fenestrules. In the general aspect of the celluliferous surface and the sinuous course of the branches, the species makes a close approach to some species of the genus *Retepora*; but the presence of non-poriferous dissepiments and the existence of a keel separating two rows of cells seem to justify its reference to the genus *Fenestella*, of which, however, it cannot be regarded as a typical member. The keels are so prominent, that specimens, especially when seen from the non-celluliferous side, often exhibit nothing except the carinæ projecting above the matrix.

Locality and Formation.—Hamilton Group; Bartlett's Mills, near

Arkona, Township of Bosanquet; and cutting on the Grand Trunk Railway near Widder, Township of Bosanquet, Ontario.

Ceramopora Huronensis, Nicholson. Plate II. Figs. 5, *5a*.

Polyzoary forming small patches or crusts, of a rounded or irregular form, from one-quarter to one-third of a line in thickness, growing parasitically upon foreign bodies, and rarely exceeding three or four lines in diameter. Cells radiating from a central or excentric point, about six in the space of one line, partially immersed, and elevated towards their mouths, which, when perfect, are of a sub-triangular or crescentic form.

This species resembles young examples of *Ceramopora Ohioensis*, Nich.; but is distinguished from adult examples of the same by forming small parasitic crusts, composed of a single layer of cells, which radiate from a generally central point. The cells are also to a greater extent immersed, and are not in such close contact. From *C. incrustans*, Hall, the present species is separated by its smooth, not nodulose or tuberculated surface. *C. Huronensis* somewhat resembles the figures of *Berenicea* (*Diastopora?*) *irregularis*, Lonsd.; but the latter is stated to possess round cell-mouths, and the published description is not sufficiently detailed to allow of a close comparison.

Locality and Formation.—Hamilton Group, Arkona, Township of Bosanquet, Ontario. Growing on the exterior of *Cystiphyllum vesiculosum*, Goldfuss, and *Heliophyllum Halli*, Edw. and H.

Retepora Trentonensis, Nicholson. Plate II. Figs. 4–*4b*.

Polyzoary forming a fan-shaped expansion, composed of slightly divergent, sub-parallel branches, which have a width of about one-third of a line. The branches are more or less sinuous in their course, and divide dichotomously at short intervals, usually uniting with adjacent stems so as to form an open network, the fenestrules of which have an approximately oval shape, and are from one to two lines in length. The cells have the appearance of being oblique to the surface, and there are four, five, or six rows of them in a branch. They are also present upon all the areas formed by the anastomosis and conjunction of contiguous branches. The cell-mouths are poorly preserved, but appear to have a long oval shape. The non-celluliferous side is strongly striated with wavy or straight longitudinal striæ or ridges.

This species is only known to me by several more or less imperfect specimens, from which some of the essential characters cannot be determined. It appears to be a genuine *Retepora*, and to be most nearly allied to *R. Hisingeri*, M'Coy; but the fenestrules of the latter are much smaller, and more regular in their dimensions, whilst the non-poriferous side is minutely granular. In *R. Trentonensis*, on the other hand, the fenestrules are large and irregular, and the non-poriferous side is strongly striated. In the general shape of the frond, it resembles some of the later *Fenestellæ*, such as *F. laxa*, but it is clearly not referable to this genus.

Locality and Formation,—Trenton Limestone, Peterborough, Ontario. Collected by Mr. George Jennings Hinde, F.G.S.

EXPLANATION OF PLATE II.

Fig. 1*a*.—*Heterodictya gigantea*. A broken frond, of the natural size. The specimen is split longitudinally along the line of the central laminar axis, and thus shows the bases of the cells.

Fig. 1*b*.—Portion of the same, near its smaller end, enlarged to show the penniform arrangement of the cells.

Fig. 1*c*.—Transverse section of the frond, of the natural size.

Fig. 1*d*.—A few of the cells of the same viewed in profile, showing the tabulæ. Enlarged.

Fig. 1*e*.—A small portion of the surface greatly enlarged, showing the shape of the bases of the cells. On the left hand side of the figure, a portion of the longitudinally striated laminar axis is preserved.

Fig. 2.—*Ptilodictya cosciniformis*, a broken specimen growing on *Heliophyllum Halli*. Of the natural size.

Fig. 2*a*.—Portion of the same enlarged, showing the meshes of the network, and their striated borders.

Fig. 2*b*.—A portion of the same still further enlarged, showing the form and arrangement of the cells and the interstitial tubuli.

Fig. 3.—*Fenestella Davidsoni;* a small portion of the non-poriferous side. Of the natural size.

Fig. 3*a*.—Portion of the same enlarged.

Fig. 3*b*.—Portion of the poriferous side of another specimen of the same, enlarged.

Fig. 3*c*.—Small portion of a branch of another example of the same, greatly enlarged.

Fig. 4.—Fragment of *Retepora Trentonensis*, of the natural size.

Fig. 4*a*.—Portion of the same enlarged, showing the arrangement of the cells.

Fig. 4*b*.—Portion of another example of the same, enlarged; showing the striated non-poriferous surface.

Fig. 5.—A small crust of *Ceramopora Huronesis*, growing on *Heliophyllum Halli*, enlarged.

Fig. 5*a*.—Portion of the same, greatly enlarged, showing the form of the cells and cell-mouths.

V.—Modern 'Vulcanicity.'[1]

By J. Clifton Ward,

Assoc. R.S.M., F.G.S., of H.M. Geological Survey.

The theory proposed of late years by Mr. Mallet to account for volcanic and earthquake phenomena, while having a charm about it from its very simplicity, is one which must nevertheless meet with very decided criticism from geologists.

Mr. Mallet sees "linked together, as parts of one grand play of forces," the elevation of mountain-chains, the production of volcanos, and the origination of earthquakes. His theory, however, necessitates the following suppositions:—

1. "That the geological doctrine of absolute uniformity cannot be true as to Vulcanicity. . . . Its development was greatest at its earliest stages." (p. 75.)[1]

2. That the movements of elevation and depression at the present time are "slow and small," but these, "at a much remoter epoch, acted upon a much grander and more effective scale." (p. 62.)[1]

On page 47[1] the "stratigraphic geologist" is described as one who discerns "a change in the order or character" of the "fused masses which have come up from beneath. He sees immense outpourings of granitoid or porphyritic rocks that have welled up and overflowed the oldest strata. . . . Later he sees huge tables of basaltic rock

[1] Introductory Sketch to Palmieri's Vesuvius.

poured forth over all." Such products, which the author says are "commonly called plutonic," he distinguishes from those of the volcano by being "*not explosive.*"

Does it not seem that Mr. Mallet is here making a difference between action from below in the early stages of geologic *history* and that action in modern and recent geologic times which does not exist in fact?[1] Volcanic products, both sub-marine and sub-aerial, of the most unmistakable character, occur in rocks of all ages down to the base of the Lower Silurian. Basaltic lavas, in which the component minerals seem to have crystallized in the very same order and under the same conditions as in modern flows, have now been traced back to periods of the world's history before, apparently, vertebrate life came into existence, and when the very ancient order of Graptolites flourished. There is nothing to mark the old sub-aerial volcanic products of Cumbria, and the sub-marine volcanic products of Snowdonia, from those of recent sub-aerial or sub-marine volcanos, *except* the metamorphism which the older rocks have been inevitably subject to, but which has seldom succeeded in obliterating their original character as a whole. There would seem to be as little doubt that 'Vulcanicity' presented phenomena of an '*explosive*' character, characteristic of the volcano, in the English Lake-district during the middle of the Lower Silurian, as that such phenomena now occur on the shores of the Bay of Naples.

But, if this be so, since our geologic history is, properly speaking, bounded by the lowermost of known sedimentary formations, it surely is not safe to say that there is any *essential* difference between modern 'Vulcanicity' and that which prevailed at the earliest stages of the Earth's history.

Let us now examine a little into the truth of Mr. Mallet's supposition that "the great masses of the mountain-chains were elevated" during the "earliest stages" of Vulcanicity. He evidently regards it as unlikely that *great* movements of elevation and depression are now taking place, such as result in the formation of mountain chains or in the depression of such beneath the waters of the ocean, although he does not deny that such chains "may be possibly increasing in stature year by year, or at times; but in any case at a rate almost infinitesimally small in its totality over the whole earth to that with which their ridges were originally upreared." (p. 63 *op. cit.*)

Are there, however, any legitimate reasons for supposing that the movements of elevation and depression were in the earlier course of geologic *history* more rapid and sudden than at present? Is there any evidence, for instance, that in times so far back as the Silurian, great elevations or depressions of land took place at all *rapidly*? Can we with any show of truth assign the origin of the leading chains of mountains to the earliest geologic ages? To answer these questions aright, we must consider denudation as well as upheaval and depression. Prof. Ramsay has shown that in Wales the many thousand feet of strata formed during the Lower Silurian period were upraised, contorted, cleaved, and extensively denuded before the

[1] See also Mr. Scrope's criticism in GEOL. MAG. January, 1874, page 31.

Upper Silurian beds were deposited upon them. Can any one conceive of such a denudation as is here implied being effected during a more or less speedy movement? A sweep of waters during some rapid action could not have effected the truncation of many thousands of feet of contorted strata, as Mr. Mallet will probably allow. But given such an action as is now going on around our coasts, and given long periods during which denudation could take effect upon land being slowly upraised, and then as slowly depressed, such an amount of work done between the deposition of the Lower and Upper Silurian strata can be realized. Or to take another example. In Cumberland, conglomerates assigned to the Upper Old Red, or perhaps with more truth to the base of the Carboniferous, lie unconformably upon Upper Silurian beds, upon the Cumbrian Volcanic Series, and upon the Skiddaw Slate. At the close of the Upper Silurian period, the Skiddaw Slate of the Lake-district was probably buried beneath at least 12,000 ft. of volcanic rocks and some 14,000 ft.[1] of Upper Silurian strata; yet between the period of deposition of the uppermost of the Kendal Silurians and the formation of the Conglomerate of Mell Fell, there must have been a removal by denudation of this 26,000 ft. of rock, to say nothing of any thickness of Skiddaw Slate which may have been swept away also. I believe that this denudation took place during the first upheaval of the present Lake-district group of mountains, and it is hard to conceive of any process by which it could have been effected other than the slow but sure gnawing and planing action of the sea upon the slowly rising tract, and the action of atmospheric powers upon those parts fairly above the sea-level. Such a denudation, carried on by such means, gives a forcible idea of the length of the Old Red Sandstone period, and there exists somewhere a thickness or an extent of strata formed during that period, strictly correlative with the amount of denudation produced. If we are to believe that the denudation of a great thickness of rock could be effected during a rapid rate of elevation, we must also believe that a great thickness or extent of strata could be as rapidly deposited. But we know from fossil evidence that sedimentary deposition has been in most, if not in all cases, exceedingly slow; therefore the denudation must have been proportionately so.

With regard to the existing mountain-chains, evidence is not far to seek, showing that *in the main* their formation dates from recent geological periods. If all such giant chains as the Alps or the Himalayas could be proved to be of early Palæozoic origin, and such diminutive mountain groups as those of Wales and Cumberland to be of recent origin, then indeed one might be inclined to argue that forces which raised the former had well-nigh spent their power, and were now only equal to producing slow elevations of 2000 or 3000 feet. But when oftentimes the very reverse of this is found to be the case, when the mountain groups of Cambria and of Cumbria are representatives of *some* of the earliest tracts of land, when the rocks forming the bulk of the Alps and the Himalayas were being formed

[1] Thickness of Upper Silurian in the Kendal district, according to Mr. Aveline.

beneath oceanic waters long ages after the mountains of Wales and Cumberland first began to take form, and when therefore the principal mountain-chains are but infants in age as compared with the Snowdon of Wales and the Scafell of Cumberland, it is surely illogical to assume that the *great* movements of elevation and depression were confined to the earliest stages of Vulcanicity.

There is another statement made by Mr. Mallet which must strike every working geologist. Geology, it is said, must make poor progress, "until all who profess to be geologists shall have learnt that, to make sound progress, they must first become mathematicians, physicists, and chemists." Now no one will deny that geology derives very material assistance from every other branch of science, the students of science forming together one great mutual help society; but to affirm that "sound progress" can only be made by the geologist when he becomes mathematician, physicist, and chemist, is to withhold any hope of progression from the many, and confine it wholly to those few comprehensive minds which arise but seldom on the intellectual horizon. One of the great charms of natural science is the way in which it developes the powers of observation, and of reasoning logically on such observation, and it gives a noble independence of thought which trusts to nature, and cares not for human authority *merely as such.* Surely many, if not most of our leading geologists, who have made our science to progress so rapidly, were neither mathematicians, physicists, nor chemists, much less all three together; but they have been and are careful observers, loving students of nature, ever willing and anxious to receive help from the mathematician, the physicist, and the chemist, but *not* willing to allow these scientists to pervert ascertained facts in order to accommodate them to their own special modes of thinking. For example, we may suppose the case of a mathematician desirous of advancing the science of geology by some new theory worked out by such abstruse mathematical reasoning that the simple field-geologist could not follow the line of argument; and if the latter has reason to suppose that the facts upon which the argument is based be correct, he feels bound to acquiesce in the result. Should, however, the geologist find that the mathematician resolutely refused to believe evidence on some special point founded on the careful observation of nature—such as the production of striæ on rock-surfaces by ancient glacial action—the geologist might well hesitate to accept the mathematical conclusions upon some *other* subject at the basis of which accurate *observational* powers should have been employed.

VI.—Supplement to the Paper on West Indian Tertiary Fossils.[1]

By R. J. Lechmere Guppy, F.L.S., F.G.S., etc.

The descriptions of two of the species enumerated in my paper on the Tertiary Fossils of the West Indies having been accidentally omitted, the defect is now supplied.

[1] See the Geol. Mag. Decade II. Vol. I. (October Number), 1874, p. 433.

Leda clara. Geol. Mag. 1874, Decade II. Vol. I. Pl. XVII. Fig. 1.

Subelliptical, lanceolate, nearly equilateral, somewhat but not extremely rostrated. Disk smooth, shining; valves with a few fine close regular concentric riblets perceptible near the anterior angle, where an indistinct sulcus runs upwards towards the umbo. No distinct escutcheon. Lunule narrow, indistinctly defined. Umbones prominent. Ventral margin slightly angulated at about a third of its length from the posterior point, where an obscure carina runs to the margin from the umbo. Length 12 mill., height 6, thickness about 4 mm. Miocene, Jamaica.

In shape somewhat like *L. nasuta.* It is rather difficult to describe the smooth plain species of this genus; their differences being most generally noticeable in shape, extent of rostrum, etc. The following species have been already described from West Indian Tertiaries:—

Leda Packeri, Forbes, Eocene, Barbados.
„ *incognita,* Guppy, Eocene, Trinidad.
„ *bisulcata,* Guppy, Upper Miocene, Jamaica.
„ *illecta,* Guppy, Pliocene, Trinidad.
„ *perlepida,* Guppy, Pliocene, Trinidad.

Three species of *Nucula* have been recorded from the same formations.

Ditrupa dentalinum. Geol. Mag. 1874, Decade II. Vol. I. Pl. XVI. Fig. 11.

Tube clavate, curved, slightly irregular in diameter, gradually increasing from the smaller end, which is annulate, becoming smooth towards the middle of the shell; the lower half smooth, shining, rather suddenly thickened near the aperture, to form which it as suddenly contracts to a diameter not greater than that of the smaller third of the tube.

There are no very distinct characters by which to separate this annelid case from *D. planum* of the European Eocene. I have thought it as well, nevertheless, to indicate its presence in the Jamaican Tertiaries under a provisional name.

Crassinella.

I have proposed this name in substitution for that of *Gouldia,* preoccupied for a genus of birds. The typical species are *Cr. pacifica* and *Cr. martinicensis;* the latter occurs in the Pliocene of Trinidad.

NOTICES OF MEMOIRS.

"Sur la Corrélation des Formations Cambriennes de la Belgique et du Pays de Galles." By Prof. G. Dewalque. (From the Bulletins of the Royal Academy of Belgium, 2nd series, tom. xxxvii. no. 5, May, 1874.) Translated by G. A. Lebour, F.G.S.

After an excursion to Wales in the autumn of 1872, which I undertook in order to study the petrographical characters of the oldest formations of that region, I announced to the Academy

(Bull. 2nd ser. tom. xxxiv. p. 424) that a comparison between them and the analogous formations of our country had enabled me to establish the parallelism of the subdivisions of the Cambrian rocks in both countries. I then hoped to be soon able to draw up a detailed communication on the subject, but my health has until now prevented my doing so. As I have had occasion to lay before my pupils the results of my observations, I think it may be useful now to make known the parallelism which I believe I have determined.

I have long ago regarded our "Ardennais" formation as Cambrian, notwithstanding contrary assertions. The Cambrian of North Wales is represented, according to most authors, by the Harlech grits, the Llanberis slates, the Lingula flags, and the Tremadoc slates. The two first names are applied to two series which I consider as contemporaneous: their characters bear the same relations to each other as those of our two "devilliennes" bands of Monthermé and Furnay, which they exactly resemble, except that our quartzites are there often replaced by conglomerates. The slates of Furnay and those of Llanberis are absolutely identical.

Our "système revinien" corresponds quite as exactly to the *Lingula* flags; the likeness of the rocks is perfect.

With regard to our "système salmien," it must be noted that its lower limit is not very clear, and that it has usually undergone a peculiar metamorphism, which scarcely allows one to hope to meet with similar rocks in Wales. I think I am justified in placing it on the horizon of the Tremadoc slates, because of the position occupied by both these formations between the "système revinien" or *Lingula* flags and the great dislocation which terminates the Cambrian period. It will be noticed that the Tremadoc system is a local formation, like our "système salmien."

Some geologists may find these resemblances insufficient to establish the parallelism in question. I think I can promise that the primordial fauna will be found in our "système revinien." I have just recognized, in a specimen which had long been looked upon as indeterminable, a plant which is characteristic of the Fucoidal grits of Scandinavia, *Eophyton Linneanum*, Tor.; it comes from the "revinien" of Stavelot. This genus is also found in the *Lingula* flags of England. Some years ago I had discovered a *Dictyonema* at Spa, at the base of the "Salmien." I have several times taken my pupils to this spot, and last year several specimens were found. Since then I have assured myself that it is the *Dictyonema sociale*, Salt., of the Upper portion of the *Lingula* flags (which would tend to alter the inferior limit of the "Salmien").

I may add that I have met with the same species in the same position at Ruy, during the excursion which I made last spring with my pupils.

REVIEWS.

I.—Manual of Geology: Treating of the Principles of the Science with special reference to American Geological History. By James D. Dana, Silliman Professor of Geology and Mineralogy in Yale College, Foreign Member and Wollaston Gold Medallist of the Geological Society of London. Illustrated by over eleven hundred figures and a chart of the world. Second Edition, 1874. 8vo. pp. 828. (New York: Ivison, Blakeman, Taylor, and Co. London: Trübner and Co.)

THE name of Professor Dana, as a zoologist, a geologist, and a mineralogist, is known and honoured, not only in America, but throughout Europe. He occupies in the United States the same relation to the student of geological science that Lyell has so long maintained in England. He is the most celebrated teacher in America, and his books are adopted wherever geology and mineralogy are taught.

Nearly fifteen years have elapsed since the first edition of this manual appeared, during which time geological progress (especially in the United States) has been very considerable. Since November, 1862 (when the first edition of this work was really completed), the Surveys of California, the Territories over the summit and slopes of the Rocky Mountains, those of Minnesota, Iowa, Missouri, Louisiana, Tennessee, Illinois, Indiana, Michigan, Ohio, North Carolina, and New Hampshire, in the United States, and the Provinces of Canada, New Brunswick, Nova Scotia, and Newfoundland, have been carried out and their Reports published. These Surveys have greatly extended our knowledge of American rocks and mineral products, besides affording aid towards a deeper insight into principles and a clearer comprehension of the system that pervades the earth's structure.

Besides all this, large contributions to palæontology have been made by some of the Reports, and most prominently by the new volume of the New York series by James Hall; the volumes of the Illinois Survey by Meek, Worthen, Newberry, and Lesquereux; of the Ohio Survey by Newberry and Meek; of the California Survey under J. D. Whitney, by Meek and Gabb; of the Survey of the Territories under F. V. Hayden, by Meek, Cope, Leidy, and Lesquereux; and of Canada under Sir William E. Logan, F.R.S., by Billings, Dawson, and Hall.

Since the year 1862, through Scudder, we have our first knowledge of the insect-life of the Devonian period; through Leidy, Cope, and Marsh we have seen the meagre list of American Cretaceous reptiles enlarged, until it exceeds that from all the world besides; and through the same geologists, not only has the mammalian fauna of the American Miocene received additions of many species, but the stranger fauna of the Rocky Mountain Eocene has been first made known. Through Marsh, also, the first American Cretaceous birds have been named, and the announcement has come of a bird with teeth in sockets, like some of the higher reptiles. In addition to these we must not omit to record the labours of Newberry among the Fossil Fishes; of Hall, Meek, Billings, among the Invertebrates; of Lesquereux and Dawson among the Fossil Plants.

Nor have the labours and publications of European geologists and palæontologists been overlooked or ignored by the author.

Such are briefly the vast mass of additional geological and palæontological materials, the essence of which Professor Dana has laboured to incorporate in the New Edition of his most excellent text-book. The volume was originally so large (798 pp. royal 8vo.), that it could hardly, consistently, have been made more bulky, yet thirty additional pages have been added to the new edition, and the author tells us "the work has been, for the most part, rewritten."

If we were to take exception to anything in the book before us, it would be the weight (3 lbs.), which is very tiring to the wrists. We are disposed, on this account, to advocate the division into 2 vols. for all books weighing over $1\frac{3}{4}$ lbs.

As a suggestion for a future edition, we would ask that a couple of pages of text should be placed at the end of the volume, immediately next to, and in explanation of, the physiographical (folding) chart of the world. This could very well be done without increasing the bulk of the volume, as *three blank leaves* (= 6 pages) are inserted at the end of the book.

We hardly think the "Pre-historic Man from the Cave of Mentone," (See Geol. Mag. 1872, Vol. IX. pp. 272 and 368), which forms the frontispiece to the New Edition of Prof. Dana's work, is of sufficient antiquity to merit so much importance. There is always an element of error to be allowed for in correlating the human remains in caverns with those *Rhinoceros, Ursus spelæus,* and other Mammalia now extinct in Europe.

The illustrations throughout the book are most excellent, but they are chiefly selected from American types.

We heartily recommend this New Edition of Dana's Manual of Geology to the notice of our readers.

II.—Revue de Geologie, par MM. Delesse et De Lapparent. (Paris, 1874.)

The *Revue de Geologie,* which is reprinted from the *Annales des Mines* (tome iv. 1873), forms the eleventh volume of the Records of Geological Research prepared by MM. Delesse and De Lapparent, and contains notices and abstracts of various papers published in different countries during the years 1871–72. It is compiled with the same care as the previous volumes, and, independently of the *resumé* of the memoirs noticed, is a useful addition to geological literature. The matter is arranged under five different heads:—general, lithological, historical, geographical, and dynamical geology. The lithological section is fully treated, and contains the more recent observations on the composition, structure, and classification of rocks. J. M.

REPORTS AND PROCEEDINGS.

Geological Society of London.—November 18, 1874.—John Evans, Esq., F.R.S., President, in the Chair.

1. "On Fossil Evidences of a Sirenian Mammal (*Eotherium Ægyptiacum*, Ow.) from the Nummulitic Eocene of the Mokattam Cliffs, near Cairo." By Prof. Owen, F.R.S., F.G.S., etc.

The specimens described in this paper were obtained by Dr. Grant, of Cairo, in a block of the white limestone of the Cerithian Nummulitic zone, quarried extensively for building purposes in the Mokattam Cliffs. They consisted of a few fragments of the base of the cranium and a cast of the entire brain with the commencement of the myelon. The author discussed the characters presented by these remains, which he regarded as having belonged to an extinct Sirenian, probably allied to *Halitherium*, which he proposed to name *Eotherium Ægyptiacum*. The characters of the brain, as deducible from the cast, were detailed, and shown to be Sirenian. By comparison with the brains of other Sirenia, the author was led to trace a progress in the cerebral characters of the animals of this type, from its first known appearance in the Nummulitic formation of Egypt to the present day. He also inferred, from its presence in the Nummulitic limestone, that this rock had been deposited not far from a shore.

Discussion.—The President expressed the pleasure with which he had listened to Professor Owen's exhaustive paper, and said that he thought that the final remarks were of very great interest as indicating that there were probably causes for changes of form. The latest species, although perhaps the most highly organized, did not appear to be the most "long-headed."

Dr. Murie explained the distinctive characters of the four genera of Sirenian Mammals, *Manatus*, *Rhytina*, *Halicore*, and *Halitherium*, and stated that he regarded *Halitherium* as the highest form, seeing that it was a four-limbed type. He remarked that in the young *Manatus* the brain differs in form from that of the adult, which was a fact to be considered with reference to the data on which Prof. Owen's deductions were founded.

Mr. Seeley said that he had no doubt the brain was Sirenian, and indicative of a new genus. The existing genera differed from it, in his opinion, in having the Sirenian characters more strongly marked rather than in showing a higher cerebral type. In general form the brain reminded him rather of a Carnivore than of a Sirenian; and he thought it indicated affinity with a generalized Carnivorous type more than with the living Sirenians.

Mr. Bauerman stated that the section from which this fossil was obtained is about 600 feet high, but the quarries referred to by the author were within about 100 feet of the top, in what had been regarded by Dr. Le Neve Foster and himself as a shallow-water deposit. The lower parts of the Cliff are very like the Chalk with flints, except that they contain Nummulites.

Mr. Charlesworth remarked that the fossil now before the Society was exceedingly interesting, as indicating the extension downwards in time of the Sirenian type. He stated that he did not believe that the English *Halitherium Canhami* was of Miocene age.

Dr. Leith Adams said that the Maltese *Halitherium* was truly Miocene.

Prof. Owen briefly replied, and concluded by hoping that the objections to any of his conclusions, if reported, would be accompanied by their grounds.

2. "On the Geology of North-west Lincolnshire." By the Rev. J. E. Cross, M.A., F.G.S.

The district treated of is that lying between the three rivers, Humber, Trent, and Ancholme. The Liassic and Oolitic beds were described, from the Keuper (found in the bed of the Trent) to the Cornbrash (the highest Oolitic stratum existing on this line). The existence of the Rhætic beds was held to be doubtful; the bone-bed and the shell *Avicula contorta* have not been found. On the other hand, the Lower Lias has a large development; and the recently discovered Ironstones of Frodingham and Scunthorpe were shown to lie in this formation, the zone being that of *Amm. semicostatus.* Higher up the series the zone of *Amm. margaritatus* seems to be wholly wanting, and the Marlstone series has dwindled to a bed of 8 feet in thickness, locally termed the *Rhynchonella*-bed. The Upper Lias is represented by clays not much explored.

As regards the Oolites, the "Lincolnshire Oolite" is the prevailing rock; but a lower band, called "Santon Oolite," was distinguished from it, containing a different fauna. Above the Lincolnshire Oolite a greenish clay, capped by Cornbrash, represents the great Oolite formation; and beyond this the alluvium of the Ancholme valley covers everything, till the Chalk rubble and the Chalk wold rise above it to the eastward.

Discussion.—Mr. Etheridge spoke as to the excellence of the paper, which contained a most useful collection of facts. Two of the species of Ammonites exhibited were rare, being new to Britain, and only previously known in France and Germany, showing and confirming the wide distribution in space of certain forms of this group. An important feature in Mr. Cross's paper consisted in his determining and correlating the zones of life in his area with those of the south and west of England, especially as regards the lowest part of the Lower Lias. The fixing the true position of the Frodingham ironstone and its associated Fauna, fully establishing its place, thickness, and value, and finally settling the point at issue as to its being on the same horizon as the "Cleveland seam," is also of high importance.

Mr. Judd remarked on the interest attaching to this communication, not only as describing a district but little known to Geologists, but also as furnishing us with evidence of very fine developments of geological horizons which, elsewhere in this country, are represented only in a very imperfect manner, or not at all.

Mr. J. F. Blake remarked that though the author had found no exposure of beds between the *Angulatus*-zone and the Keuper, they probably existed, as they occurred both to the south and to the north in Yorkshire, across the Humber. He agreed with the author that the ironstone of Lincolnshire was on an entirely different level, and was totally unrelated to that of Yorkshire, the true equivalent of which, though here only eight feet, was much thicker, though not valuable, across the Humber. The Pecten-beds mentioned were characteristic of the same zone in Yorkshire as in Lincolnshire; but in the former county they contained no iron except in the form of pyrites. The thinness of the upper beds, as contrasted with the thickness of the lower, showed a veritable thinning out of them, which was continued into Yorkshire, where some of the fossiliferous bands of the Inferior Oolite described by the author appear to be altogether wanting.

Prof. Hughes said that he thought we should be careful not to infer too hastily an interruption in the continuity of deposition from the absence of certain fossils from the horizon at which they occur in other sections.

CORRESPONDENCE.

DEEP-BORING IN PRUSSIA, ETC.

Sir,—It may interest some of the readers of the Geological Magazine to learn that a boring has lately been carried out by the German Government at Sperenberg, twenty-five miles south of Berlin, which has reached the surprising depth of 4040 feet! and is the deepest boring in the world (not *even* excepting America)! It is almost all through the Saliferous Rocks, Triassic series (Keuper, Muschelkalk, and Bunter), and was finished in 1872. The boring is done with rods, but the details I have not yet learned.

The following Extract from a letter, 19th Nov., 1874, from Thos. J. Bewick, Civil and Mining Engineer, to Major Beaumont, M.P., Managing Director, Diamond Rock-Boring Company, Limited, 2, Westminster Chambers, London, may prove of interest, as showing what can be done by means of Diamond Boring.

"Bohemian Broad-Bore-Hole.

"Actual boring was commenced on the 15th July last. On 8th inst. the depth was 1931 Vienna feet, equal 2001 4″ English feet. At commencement bored 35 feet, when stopped by fall of ground. 13′ more, equal to 48′, lined with 5 inch tubes, and then bored up to 96 feet with 4 inch crown. Lost water by a cleft at 73 feet. Bored to 180 feet with 4 inch crown. Again lost water from tubes not being close to the bottom. Withdrew 96 feet of tubes, and widened the whole to 180 feet with 5 inch crown. Lined with 5 inch tubes to that depth, and continued with 3 inch crown to bottom. No more tubes required after 180 feet. Usual recent rate of boring 30 to 40 feet per day of 24 hours (2 shifts of 12 hours each). Boring is in New Red Sandstone formation. Conglomerate occurred from 520 to 580 feet, 680 to 850 feet, and 1200 to 1510 feet, equal to 540 feet in all. The pebbles were firm, with but few loose stones. The Conglomerate consists of porphyry, Silurian shales, granite, and quartz. The rest of the strata are the usual Sandstones, Shales, and Marls in the New Red Sandstone formation."

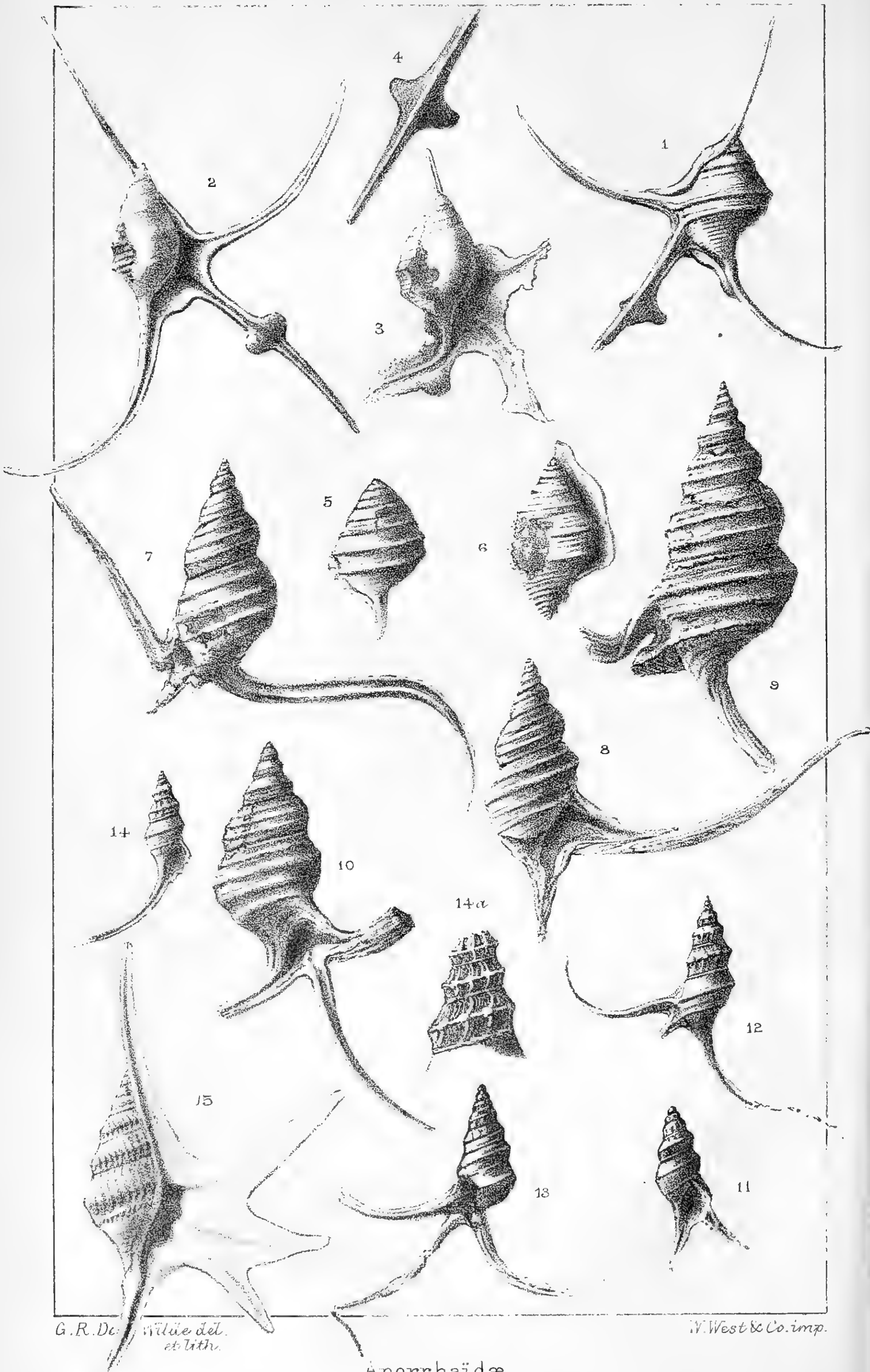
I can only hope the Sub-Wealden Exploration may succeed in attaining as great a depth as that of Sperenberg, near Berlin.—J. P.

ENGLAND AND FRANCE IN THE GLACIAL EPOCH.

Sir,—In a clever and able article by Mr. Thomas Belt, F.G.S., published in the "Quarterly Journal of Science" for October last, that gentleman advocates the theory of a great river flowing *southwards*, towards the close of the Glacial epoch, down what is now the English Channel, and embracing the Rhine, the Thames, the Seine, and other rivers in its course.

This is, I believe, contrary to the generally received notion that the Straits of Dover had not then been cut, and that the Thames flowed *northwards* to join the Rhine.

Perhaps Professor Prestwich or some other of your Quaternary Geological readers will relieve my mind by telling me which is the *right faith*. J. Sussex.



G. R. De Wilde del. et lith. W. West & Co. imp.

Aporrhaïdæ,
Recent (Fig 15.) & Fossil (Figs 1-14.)

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. II.

No. II.—FEBRUARY, 1875.

ORIGINAL ARTICLES.

I.—On the Gault *Aporrhaïdæ*.

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

(PLATE III.)

IN this paper I purpose giving a history and description of the Cretaceous group of *Aporrhaïs*, as far as they are at present known to me, especially of those forms which are so beautifully preserved in the Gault of Folkestone, and so-called Upper Greensand of Blackdown. I regret that I cannot include the *Aptien* and *Neocomien* species, but the collections at present open to me are too meagre to give anything like a complete account of them. In the whole group there are even now many points which require further research; the correlation of some of the forms with those on the Continent is still unsatisfactory, from the difficulty experienced in comparing actual specimens. The figures available, even in the most modern works, appear in some cases to have been restored, and not therefore to represent the form of any shell that has been really met with.

As a result of my examination, I think it very probable that all or most of the British Cretaceous fossil forms are met with in similar deposits abroad; but this uncertainty in figuring, and the practice of describing new species from single and generally imperfect specimens, has prevented me from placing similar, and what appear closely allied forms under the same specific names.

I believe the list appended from the Gault at Folkestone to be a complete one, so far as the forms are at present known, as it is based on an examination of many hundreds of specimens. As regards the Blackdown list, I find I cannot confirm the statements of the occurrence of many species mentioned by other writers. I have seen and examined the collections of the British Museum, Geological Museum, Geological Society's Museum, and many private cabinets, with this view, but unsuccessfully. I have also reason to believe that many undescribed species exist from the Upper Greensand, Chloritic-marl, and Chalk, in cabinets which I have not yet seen, and I shall be obliged to any one who would inform me of them.

Forbes and Hanley, in the British Mollusca, vol. iii., in 1853, first included *Aporrhaïs* with the *Cerithiadæ*. They considered them to constitute a group intermediate between the holostomatous and siphonostomatous *Pectinibranchiata*, and to be closely allied to *Turritellidæ* on one hand, and *Scalaridæ* on the other; they also state that the relationship to *Scalaria* is better seen and traced through *Aporrhaïs* in fossil than in living examples of the family: some fossils of the last-named genus, as will be seen, approach very closely to *Scalaria.*

Gwyn Jeffreys, in his British Conchology, 1857, describes the *Aporrhaïdæ* as follows:—

"*Body* spiral; mantle large and loose, forming a very short branchial fold at the partially channelled base of the shell, which it lines; snout cylindrical, contractile, notched in front; tentacles awl-shaped, separate; eyes on bulgings or short stalks, at the outer base of the tentacles; foot small, lanceolate; gills arranged in a single narrow plume; odontophore enveloped in a sheath, straight; rachis single; pleuræ or uncini three, plain-edged."

"*Shell,* when young, spindle-shaped, never umbilicate; spire turreted and tapering; mouth widely expanding; operculum small, horny, pear-shaped, increasing by semielliptical layers; nucleus nearly terminal at the base of the mouth."

The animal differs from those of *Rostellaria, Strombus,* and *Pteroceras,* in the eyes being at the base, and not at the extremity of the tentacles, and in the tentacles not being bifurcate, etc. Models of both may be seen in the British Museum. Its mode of growth is similar to that of the *Strombidæ.* When young it developes in the form of a cone or spindle, and increases in the usual manner of spiral shells: but at a certain point it ceases to grow spirally; a rib of enamel appears along the mouth, the borders of which thicken and contract; the lip dilates, expands, and becomes cut up into spikes or digitations till the outer lip is complete, when the subsequent growth takes place by adding fresh layers inside.

In the young state it extremely resembles *Cerithium* and *Scalaria,* a fact noticed by Swainson; when the canal is developed, and before the wing begins to grow, its appearance is that of a *Fusus.*

Monstrosities are not uncommon, both in recent and fossil forms, in the shape and size of the pterygoid process.

The term *Aporrhaïs* was applied by Aristotle to probably what is now known as *A. pes-pelicani* of the Mediterranean and British seas, and was derived from the word Ἀποῤῥέω "to flow out," and was on his own testimony suggested by the spouted form of the shell; he also noticed the operculum (ἐπικάλυμμα or πῶμα). Aldrovandus and then Gualterius used the term for Lamarck's genus *Pteroceras.* Petiver in 1711 restricted the term to shells of the present family of *Aporrhaïdæ.* Da Costa in 1778 adopted it as a generic appellation, but included it with *Strombus, Pteroceras,* etc., in Lamarck's family of *Alata.* The term *Chenopus* was needlessly introduced by Philippi in 1836, who, however, first rightly defined and understood the characters of the genus, and has been frequently used since.

I have referred somewhat at length to the history and characters of the recent family, as it is not separated from the *Strombidæ* by most conchologists; and undoubted *Aporrhaïdes* are still sometimes described as *Rostellarias* by geologists.

Morris and Lycett, in the Mollusca of the Great Oolite (Pal. Soc.), instituted a genus *Alaria* to receive those Jurassic forms which have no posterior canal, with the left lip thin, never thickened; left lip not, right lip sometimes, extended on penultimate whorl. Many Cretaceous forms, however, have a rudimentary canal, which would make it embarrassing to adopt the character as generic, and would cause nearly identical species to be separated, and thus break up natural groups. M. Piette distinguishes *Alaria* by the wing being *applied to the last whorl but one, and never adhering to the rest of the spire.* This character is not of the slightest generic importance in a shell so subject to variation; in recent species the pterygoid process is sometimes attached to the second whorl, sometimes quite to the apex of the spire. See Pl. III. Fig. 15, *A. pes-carbonis*, recent.

Mr. R. Tate, in a paper in the Geol. and Nat. Hist. Repertory, 1865, established a sub-genus *Perissoptera*, with *A. occidentalis* as its type, to receive those species which have a nearly entire and broad wing, prolonged into a recurved point, and attached to the last whorl but one. This sub-genus has not been recognized by zoologists in the case of *A. occidentalis*, and Mr. R. Tate included *A. marginata*, which certainly is nearer *A. pes-pelicani*. A simple division into groups will for the present meet all he seeks to establish.

Aporrhaïdæ appear first in the Jurassic age, and reached their greatest development in the Cretaceous seas; the number of species in this genus far exceeds that of any other Gasteropod at Folkestone, and individuals are so numerous that hundreds of casts may be picked up in a few hours by the collector. The family decreased in importance in Tertiary times, and are now, in common with many other Cretaceous families, only represented by a few species. There appear to be only three species known, yet they are types of the largest Cretaceous group.

The following may be taken as the characters of *Aporrhaïs* of Da Costa. Shell turreted, strong, moderately elongated; canal at base beak-like and shallow, never very long, differing in this respect from most Cretaceous forms; whorls numerous, variously ornamented with nodules or striæ; mouth angulated, outer lip expanded and thickened, detached from the spire at upper part (not a constant character), either simple or expanded into claw-like digitations, corresponding to well-marked keels on the last whorl.

With regard to the so-called British Cretaceous *Pterocerata*, I have long felt that they were unnecessarily separated from the family of *Aporrhaïdæ*, with which they are constantly found associated, and with which I have always considered they have the greatest affinities. The principal difference is in the length of the spire, the general plan and ornamentation of the shell being similar. The attachment of the posterior digit to the spire, which has chiefly led to their being classed with *Pterocera*, is no longer a character by which they can be separated, as the figure (Pl. III. Fig. 15) of a specimen of *A. pes-carbonis* in the British Museum clearly shows. This figure is very similar in arrangement of the digits, canal, and ornamentation, to the fossil shown in Fig. 2. On the other hand, the aspect of the fossil, which may be taken as a type of our so-called *Pterocera*, is most unlike that of the recent *Pterocerata*: the lip is less dilated and thickened, the columella and aperture are not ridged, and the digitations are not so variable; the whole shell is much smaller and more delicate. The recent *Pterocerata* appear to be a modern group, and to be in part the representatives of the *Aporrhaïdæ* of Cretaceous times. Some of the figures given by D'Orbigny of Continental forms approach, however, more nearly to recent types.

The British Cretaceous *Aporrhaïdæ* may be divided, by the forms of the wing and their ornamentation into four groups, as follows:

Group 1.—Spire short, ovate, longitudinally striated, carinated, lip furnished with three to four long flexuous recurved digitations; anterior canal resembling digits in form.

Type:—Aporrhaïs retusa, J. Sby. Plate III. Figs. 1–6.

Synonyms....
- *Rostellaria retusa*, J. Sby., 1836.
- ———— *bicarinata*, Desh., 1842.
- *Pteroceras* ————, D'Orb., 1842.
- ———— *retusa* (Forbes), 1845. Sow. sp.
- *Harpago retusus* (Gabb), 1861. Sow. sp.

Description.—Shell of a delicate shape, broad and ovate; the spire short, forming an angle of $37\frac{1}{2}°$; whorls six, inflated, convex, of which the last is equal in depth to the other five; each with two keels, the anterior being hidden by the suture, so that the last whorl alone is seen to be bicarinate, the other whorls seeming to have a single prominent ridge at or about the middle. The chief keels are elevated, narrow and subacute, the spaces between them are ornamented by spiral striæ, which are extremely variable in number. On the last whorl, from two to seven or eight thread-like lines occupy the space between the posterior keel and the suture, one to three or perhaps four between the keels, and from six to twelve between the anterior keel and the canal; these last sometimes extend over the canal and the dilatation which unites it with the anterior digit. The spire is seen by aid of lens to be finely ribbed, the riblets being more distinct in crossing the keels: from the third whorl to the apex the keel is often undistinguishable, and the riblets so distinct as to cause a reticulated appearance. The ventral side of the shell is encrusted to the summit with a smooth polished enamel, to which encrustation is due the gibbosity of the last whorl.

Each of the two keels is the basis of a very long flexuous digitated process, which is acutely triangular above, and deeply canaliculated ventrally; the anterior digit being very thick for half its length, where there occurs a dilated node, which is flattened and triangular on its under-side; from this point the digitation tapers to, and is finely pointed at its termination. A third, the uppermost process, prolongs and terminates the mouth into a canal posteriorly, and is recurved backward over the spire, extending far beyond it. The anterior canal is very long and slender, being recurved rather abruptly backwards at about two-thirds of its length. The lip in some adult forms (probably very old individuals) is excessively dilated, forming a palmate expansion, uniting the digits for part of their length (see Fig. 3). The mouth is narrow, oblique and oblong. The spire measures without canal ·016; canal alone ·025; digits ·030.

Distribution.—This is a most widely distributed form, being found abundantly at Folkestone, Lyme Regis, and at Cambridge,[1] Blackdown and Devizes, Ringmer,[2] etc. *I have seen no specimens except from Folkestone and Lyme Regis.* The same, or an allied form, is found in the Aptien beds of Folkestone. Morris gives it from Atherfield, but this is no doubt an error.

On the Continent it has been found throughout the Paris basin, Doube, Varennes, Ervy, Saxonnet, Perte-du-Rhône, Sainte-Croix, but I have not seen it described from Aachen in German works.

History.—First described in 1836 as *Rostellaria retusa* by J. Sowerby, in Fitton, Geol. Soc. Trans., vol. iv. p. 344, pl. 18, fig. 22. I cannot find the type or any specimen from Blackdown, and there is a doubt whether the same species is intended. Sowerby says, "It has only one elongated narrow branch to the lip. The surface between the striæ is particularly smooth." Should the Blackdown form prove distinct, Deshayes' name of *bicarinata* must be adopted for it.

Leymerie, in 1842, in the Mém. Soc. Géol., figured a young specimen as *R. bicarinata,* and noticed the more delicate ornamentation, "spire delicately '*quadrillée*' by the intersection of fine transverse ribs and of slightly oblique longitudinal striæ." In the same year D'Orbigny figured this species in his Pal. Fr. Terr. Crét., vol. ii. p. 307, pl. 208, figs. 3 and 5, from the Albien of Aube and Ardennes, but in an unsatisfactory manner. He observes, "Young or old, it is clearly characterized from all other forms by its singular shape."

In 1845 Forbes mentions it in the Quarterly Journal. In 1849 Pictet and Roux figured and described this shell in the Moll. foss. Grès-verts, p. 263, pl. 25, fig. 11, but did not consider it identical with that in Fitton's memoir. Geinitz, in his Quader-sandsteingebirge, also figures this shell as *Strombus* (*Pterocera*) *bicarinata,* t. ix. fig. 4. The three names in D'Orbigny's Prodrome are probably synonyms for this one species. In 1854 Professor J. Morris, in his catalogue, considers it distinct from *P. retusa* of Blackdown. The same year Cotteau, and in 1858 Leymerie, mention it from the Yonne. In 1859 Dr. Chenu figured *P. bicarinata* in the Man. Conch., p. 260. It occurs in Gabb's list of 1861, pp. 56, 71, under Klein's name of *Harpago* (1753). In 1864 Pictet and Campiche and Pictet and Roux described it. The figures in Pictet and Campiche, pl. xci. figs. 5 to 8, differ, however, from our British form, except fig. 5; perhaps owing to their being figured from imperfect specimens. In 1865 Briart and Cornet, Descr. Min. de la Meule de Bracquegnies, p. 17, pl. 2, fig. 3, figure a specimen with dilated lip as *P. macrostoma,* Sow., a species it in no way resembles, and also figure *P. retusa,* but with a different form of wing. In the same year Mr. R. Tate described *P. retusa,* but separated it from

[1] Seeley. [2] Fitton, Morris, etc.

P. bicarinata, which he says *he had never seen,* but giving them both from the Gault of Folkestone, *where certainly only one species is found.* Mr. Tate describes *P. bicarinata* as follows:—"Possesses two keels, each corresponding to a long digitation, an anterior canal, and a posterior expansion towards the spire." This description applies equally to *A. retusa,* in fact the two names are synomyms for the same species. In 1869 Jaccard cites it from the Lower Gault of Ste.-Croix.

Other species belonging to this group.

P. Moreausiana, D'Orb. Lower Greensand.

P. Fittoni, Forbes. Probably synonymous with above. Lower Greensand.

P. globulata, Seeley, 1861, Greensand, Cambridge, appears to differ only in size.

A. bicornis, P. and C., from the Upper Gault, very closely resembles . *retusa,* but seems to have had a rather longer spire.

P. macrostoma, Briart and Cornet, is a similar form with dilated lip; quite distinct from the *R. macrostoma,* Sow.

R. ovata, Münster, Green Chalk of Haldem, bears considerable resemblance in form, but the figure in Goldfuss, Petr. Germ., shows a pointed spine in the middle of second whorl, as in Oolitic *A. spinigera.*

Chenopus Couloni, de Loriol, 1861. No keels, except two on body-whorl, spire longer than *P. Moreausiana.* Neocomien of Mont-Salève.

Two undescribed species from the Grey Chalk of Dover.

Group 2.—Shell pupæform, with keels prolonged in two very long narrow flexuous digits, anterior canal long and resembling the digits.

Type:—Aporrhaïs cingulata, Pictet and Roux. Pl. III. Figs. 7–10.

Description.—Shell elongated and pupæform, composed of about eight convex inflated whorls, the last of which is smaller than is required to form a regular cone, being but one-sixth more in diameter than the preceding whorl. Whorls with four simple longitudinal salient but rounded keels, without trace of tubercles. On all but the last, the two median keels are equally prominent; of the other two, the anterior is very small, and is nearly concealed by the suture; the posterior is more or less subordinate to the two median keels, and is situated midway between them and the suture, its relative prominence being very variable. On the last whorl the posterior median keel is much more pronounced than the other, and is prolonged into an exceedingly long narrow flexuous digit, which is convoluted, taking a half turn near the lip, and then curving gradually upwards, attaining a length exceeding twice that of the spire. The process is grooved underneath. The anterior keel forms another downward spiked digit not convoluted, and of less length. The anterior canal is about one and a half times the length of the spire, is flexuous, and generally abruptly recurved, or bent backwards at nearly a right angle to the axis of the spire. The aperture is oblique and pyriform. The lower portion of the last whorl may sometimes be longitudinally ribbed; on the first whorls the posterior median keel predominates more or less to the exclusion of the others. The shell without canal measures ·033, the canal ·045, wing process ·045, middle digit ·024.

Distribution.—This is a very characteristic, and I should think will prove a widely distributed, though rather rare shell. It is found in the Lower Gault at Folkestone, and in Switzerland, at Sainte-Croix, the Perte-du-Rhône, and also in France, at Dieuville, Colombières. It cannot be confounded with any other species.

History.—Pictet and Roux first described this species in 1849 in the Moll. foss. Grès-verts, p. 261, pl. 25, fig. 7, from the Gault of the Perte-du-Rhône. Their specimens were all casts. D'Orbigny included it in his Prodrome, and Pictet and Renevier found it, 1854, in the Gault of the Perte-du-Rhône. Pictet and Campiche in 1864, pl. 94, figs. 10 and 11, p. 617, figure a specimen from Folkestone, and casts from Sainte-Croix. In 1865 Tate described it in the Geol. Repert. p. 96, fig. 16; and in 1869 Jaccard mentions it from Sainte-Croix.

Type:—Aporrhaïs Griffithsii, Gardner. Pl. III. Figs. 11–14.

Description.—Shell elongated and pupæform, composed of eight very convex whorls, the last having a less diameter than is required to form a regular cone. The whorls have a central, salient, angular keel, and a second anterior keel conceals the suture; there is also a third and faintly marked keel anterior to the predominant one and midway between it and the suture. The keels are not visible in the first two or three whorls, but develope as they increase in size, all three keels being visible on the last and penultimate whorl. The whorls, except the last two, are ornamented with fine, transverse, oblique, acute, and angular ribs, wide apart, eight or nine on each whorl, which interrupt the median keel in crossing and form nodose tubercles. This ornamentation is most distinctly seen near the apex, where the keels are obsolete, and becomes less so in descending the spire. The last whorl is smoothly striated, having the three keels pronounced. The principal keel is prolonged into a narrow acutely angular process at right angles to the axis, till near its termination, where it curves gradually upwards, terminating in a fine point. A straight downward spike seems to correspond with the second keel. The anterior canal is longer than the spire, and is recurved abruptly to the left, as in *A. cingulata.* The aperture is narrow and angular, without encrustation.

In form this species bears a striking similarity to *A. cingulata*, with which I have grouped it; but the ornamentation is of a different character and the shell is much smaller. Its sculpture strongly resembles that of *R. tricostata*, D'Orb., Pal. Fr., pl. 207, fig. 5, p. 287, from the Gault of Ervy, where it is rare, and *A. triboleti*, P. and C., from the Lower Aptien of Sainte-Croix. The keels are, however, in these latter strongly marked near the apex, and the ribs are nearly obsolete. The form of their spires is also not pupæform. The shell measures without canal ·017, canal only ·022.

Distribution.—Gault of Folkestone, where it is rare.

I should perhaps have named this *A. pupæformis*, and have thereby implied the form and character of the shell; but this name was appropriated by D'Archiac in 1847 for a little-known Oolitic species. I have named it in compliment to John Griffiths, the well-known collector at Folkestone, who has furnished me with the great majority of my specimens. A comparison of specimens in cabinets supplied by him with figures of Folkestone fossils of twenty or thirty years ago, shows the useful, and let us hope not unprofitable, work he has devoted himself to.

EXPLANATION OF PLATE III.

Fig. 1.—*Aporrhaïs retusa*, J. Sby. Natural size, showing ventral side. The posterior digit is slightly lengthened from a specimen lent me by Mr. Price.
Fig. 2.—Showing dorsal side.
Fig. 3.—Specimen showing dilated lip.
Fig. 4.—Part of a shell, to show dilated node. Enlarged.
Fig. 5.—A young shell, to show mode of growth.
Fig. 6.—A young shell, illustrating the same, from the British Museum.
Fig. 7.—*Aporrhaïs cingulata*, Pictet and Roux, showing arrangement and relative position of digits and canal.
Fig. 8.—Specimen showing development of wing.
Fig. 9.—Another, with dorsal view.
Fig. 10.—Specimen showing aperture and middle digit.
By tracing and reversing Fig. 7 and Fig. 8 an illustration can be obtained of the relative length and position of the wing and canal, showing general appearance of the shell.
Figs. 11 to 14.—*Aporrhaïs Griffithsii*, Gardner, from Folkestone.
All in the author's cabinet, save Fig. 6.
Fig. 15.—*Aporrhaïs pes-carbonis*, Recent.

(To be continued.)

II.—Contributions to the Study of Volcanos.

By J. W. Judd, F.G.S.

(*Continued from page* 16.)

The Lipari Islands (*continued*).

3. *Third Period of Volcanic Activity in the Lipari Islands.*

Although, as we have already seen, the older volcanic formations of the Liparis present us with features of no little interest, yet it is on account of the cones and lava-streams, composed of rocks of singular beauty and almost unique character,—which are the product of the *latest* developments of igneous action in these islands, that the attention of geologists is most frequently directed to them.

Lofty cinder-cones, composed of snowy pumice, their vast craters breached by lava-streams of solid glass, seemingly fresh as when the fiery flood leaped from the volcano's throat, and poured with slow and tortuous current down its flanks; wide-spreading lava-fields, their horrid bristling surfaces coated by a reddish-brown crust, but exposing in grand cliff-sections the most marvellous combinations of variegated rocks;—these seen rising amidst the bright blue waters of the Mediterranean, and displayed in that clearness of outline and that vividness of colouring which only the brilliancy of an almost tropical sky can impart, constitute scenery of startling novelty and wondrous beauty—the impressions produced by which it is as hopeless to convey as it is impossible to forget. Nor is the geologist disappointed by a nearer approach to these remarkable scenes; every blow of his hammer revealing fresh examples of singular rock-structure, novel groupings of crystallized minerals, and lively illustrations of the multiform products which result from the action on rock-masses of the ever-varying combinations of many forces,—such as heat, chemical affinity, crystallization, pressure, tension, and the disengagement of imprisoned vapour and gas.

But before entering on a description of some of these remarkably interesting volcanic cones and lava-streams, composed of pumice and glass respectively, it will be well to pause in order to notice the very striking *linear arrangement* affected by the volcanic vents belonging to both the second and the third periods of igneous action in these islands. For nowhere, perhaps, is this constant feature of the development of volcanic forces—so unmistakably suggestive of the existence of subterranean fissures—more admirably and clearly illustrated than in the Lipari Islands.

Commencing with the southern part of the Island of Vulcano (see map, p. 7), the observer, standing on the summit of the Monte Saraceno, will have no difficulty in perceiving that there lie before him the remains of at least four different volcanic cones and craters, which have been successively formed through the continued shifting of the eruptive vent to more northerly positions. The great central cone of Vulcano, with its magnificent active crater, is evidently thrown up on a continuation of the same line. But an attentive study of this cone and crater-ring clearly indicates to the geologist that they are not the product of a stationary vent; on the contrary, we find clear evidence that the cone has been more than once partially destroyed by explosion and its crater re-formed. Indeed, portions of at least three successive crater-rings, which must have been clearly excentric with one another, can be easily traced. It is interesting to notice that the last eruption of this volcano (which, as will be described in a future chapter, took place only a year ago) threw up cinder-cones at the bottom of its great crater, not, however, at its centre, but at its extreme northern limit.

Again, we have proofs of the opening of a vent, still a little farther to the north, in the actual walls of the great cone, in the beautiful little crater called the Fossa Antico. The Faraglione, situated between Vulcano and Vulcanello, is a mass of volcanic agglomerates, in which mineral deposits of great beauty and value have been developed, in consequence of the permeation of the mass by acid gases and vapours; it is now burrowed over, like a rabbit warren, by the excavations which serve as houses for the workmen employed in the chemical works in the adjoining great crater; this mass of tuffs is clearly the greatly denuded and ruined vestige of a cinder-cone. Thus we find that in the island of Vulcano there exists evidence of the opening, along a single line, of at least *nine* different vents, which have given rise to eruptions differing very greatly in violence and duration.

On a continuation of the same line, we find in Vulcanello, now joined to Vulcano by a bank of cinders, three other well-marked craters. The features presented by Vulcanello are illustrated in the accompanying sketch (Fig. 6). Of these craters the newest is

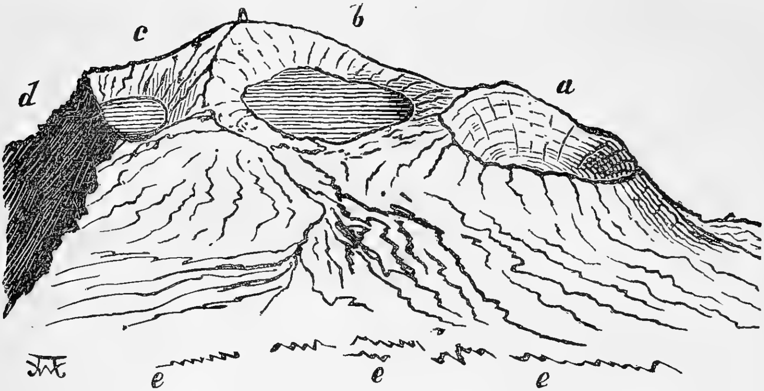


Fig. 6.—Vulcanello with its three craters as seen from the south end of the Island of Lipari. *a*. Most modern crater. *b*. Central, largest, and oldest crater. *c*. Portion of third crater. *d*. Section of cone in sea-cliff. *e*. Lava-stream.

clearly that which occupies the most southern position, and which was in all probability due to an eruption during the historical period. The most northern of the three craters of Vulcanello has had one-half of its periphery removed by the encroachments of the sea, and here we actually find a clear section of one of these small volcanic cones, as represented in Fig. 7. The central crater of Vulcanello is the largest, most ruined, and probably the oldest of the three.

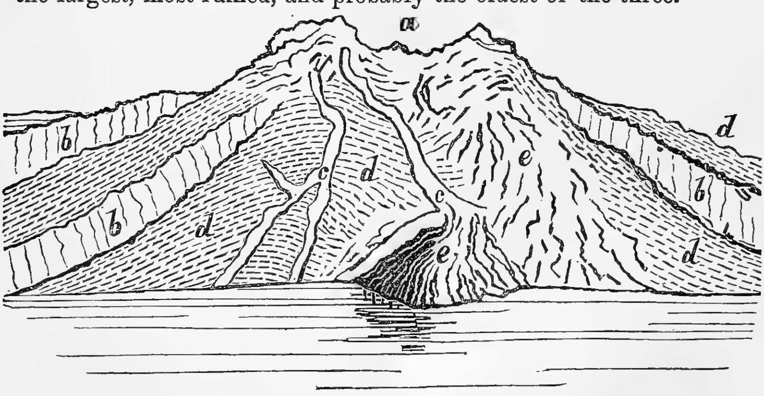


Fig. 7.—Section of cone of Vulcanello in sea-cliff (*d* in Fig. 6). *a*. Crater. *b, b*. Lava-streams. *c*. Dykes which have clearly formed the ducts through which lava has risen to the crater. *d, d*. Stratified volcanic tuffs and agglomerates, exhibiting the characteristic arrangement of the interior of volcanic cones. *e*. Portions of cliff concealed by taluses of fallen fragments

The island of Lipari must be looked upon as only accidentally separated from that of Vulcano and Vulcanello; the same line of volcanic cones and craters which we have described in the latter being clearly continued in the former. In the southern part of the island of Lipari we find at Punta Capparo, Formiche, Monte della Guardia, and Fossa del Monte, weathered and unmistakable craters and lava-streams, composed of materials of highly acid or siliceous character, namely, pumice and quartz-trachyte (Liparite), passing into obsidian, perlite, retinite, etc., and evidently belonging to the latest period of volcanic eruption. The central parts of the island of Lipari are entirely composed of the tuffs and lavas of the second period; these are, however, as we have already seen, much altered by the gaseous emanations, still represented by the hot mineral springs of San Calogero and the stufe of Bagno Secco, which must be assigned to the third period. The great central crater of Monte Sant' Angelo (see Fig. 3, page 14) is thrown up on the same great line of fissure which we have been tracing to the southwards; but on the west and east sides of it respectively we find the smaller lateral craters of Mazza Carusæ and Monte Perrara or Forgia Vecchia, the latter belonging to the latest period of eruption.

The northern part of the island of Lipari, like its southern extremity, exhibits a fine series of pumice cinder-cones and lava-streams of volcanic glass graduating into Liparite, evidently of recent origin, and forming a continuation of the same north and south line of vents. These we shall presently describe in greater detail.

Thus we have clear evidence that along a line, directed towards the earliest and great central volcano of the Lipari group, at least *twenty* distinct vents, giving rise to volcanic cones and craters of varying size, have been formed. It seems probable, as suggested by Hoffmann, that the volcanic products of Capo di Milazzo may be regarded as a continuation of the same line.

The twin volcanos of Salina (the Didyma of the ancients) with those of Filicudi and Alicudi are evidently situated on another line, which may perhaps be produced to Ustica. This line also radiates from the same central volcanic mountain.

Lastly, in Stromboli, with its linear arrangement of old and recent craters, and in Stromboluzzo, doubtless the last relic of another volcanic pile, we see evidence of a third string of volcanic vents, the direction of which points to the same great centre of igneous activity.

That the linear arrangement of volcanos, such as we have described as so well exemplified in the Lipari Islands, points clearly to the existence of great fissures in the earth's crust, along different parts of which eruptions have successively taken place, has been recognized by all geologists. Indeed, in the fissures produced at Etna during the recent eruption (1874), as described by Professor Silvestri, of Catania, in the earlier eruptions of the same mountain in 1669, 1811, and 1819, and in many analogous cases, we have had ocular demonstration that such is the case. Fresh proofs of the correctness of this conclusion are afforded by the great fissures filled with volcanic materials, with which all geologists are familiar, as traversing older rock-masses where exposed by denudation.

Nor must we forget that the volcanic band, which has been indicated as passing through the great central vent of the Liparis and Stromboli, would, if produced, strike the great earthquake-shaken tract of Calabria, and by a slight deflection pass through the volcanic districts of Southern and Central Italy; while the southern continuation of the same, passing through Lipari, Vulcanello, and Vulcano, points to Etna, the Val di Noto, and the volcanic islands lying south of Sicily. These facts are interesting, as indicating that Von Buch's classification of volcanos, according to their mode of arrangement, in linear systems and groups, cannot be sustained. All volcanic action appears to be developed along lines of fissure, though these may present very varied relations and connexions with one another, I shall take occasion, hereafter, to show that the principal of these combinations assumed by volcanic lines of fissure may be classified as radial and parallel series.

The fissures of the Lipari group afford an interesting example of the radial arrangement, with some illustration of the production of lateral or branching fractures on either side of the principal ones. The whole, however, being probably a subordinate part of a great band of subterranean volcanic action.

It is a most interesting circumstance, and one by no means devoid of suggestiveness to the geologist, that the two active volcanic vents of the Lipari Islands are situated at distant, almost indeed extreme, points of the group; and that while one of them, Stromboli, ejects materials of the most highly *basic* character—dolerite and basalt—the other produces rocks of extremely *acid* composition, quartz-trachyte (Liparite) and obsidian. The striking differences in the specific gravities of these two classes of rocks has been commented on by many geologists. As every great volcanic area may fairly be supposed to have beneath it a reservoir of materials in either an actually or potentially[1] liquefied state, we may, without adopting Durocher's notions of *universal* acid and basic magmas, suggest a possible explanation of the peculiarities of the existing volcanic phenomena of the Lipari Islands. If we imagine the area to be underlaid by a reservoir of liquefied materials which is of intermediate composition, this might have supplied the products of all the earlier eruptions of the district; and it is only necessary to suppose that, by the action of gravity, the materials (magmas) of different densities were in process of time separated from one another, while distinct fissures were opened connecting the upper and lower portions of the mass, respectively, with different parts of the surface,—to see that just such phenomena as now take place would be called into play.

[1] By a rock in a *potentially* liquefied state, I of course mean one which, either from its elevated temperature or its condition of internal tension from imprisoned volatile constituents, would assume a liquid form on being relieved from the pressure which maintains it in a solid state.

Reserving for a future occasion, when some other volcanic districts have been described, all general remarks upon the classification of the products of volcanic action, we may notice that the modern lavas of the *northern* fissure (Stromboli and Stromboluzzo) produce rocks of the most typical basic character, namely, basalts and dolerites. Abich's analyses of these lavas gave the following results—their specific gravity being between 2·86 and 2·96.

	Lava of Stromboli.	Lava of Stromboluzzo.
Silica	50·25	53·88
Alumina	13·09	12·04
Oxide of Iron	10·55	9·25
Oxide of Manganese...	0·38	—
Lime	11·16	7·96
Magnesia	9·43	8·83
Soda (with some Potash)...	4·92	4·76
Loss	—	2·78

The second of these rocks appears to have undergone a certain amount of alteration.

These doleritic lavas appear to consist mainly of an aggregation of nearly equal proportions of crystals of Labradorite felspar and augite, to which variable quantities of magnetite and olivine are added in different examples.

As is usually the case with igneous rocks of basic composition, the lavas of Stromboli only very rarely assume the vitreous condition. The scoriæ which are ejected from the active crater of Stromboli, at intervals of a few minutes only, sometimes fall so near to the observer that he can approach them while still in a soft and plastic condition, and thrust coins or other hard objects into them. These cinders are found on examination to be perfectly stony in character; but they are completely full of vesicles, formed by the escape of volatile materials from their midst, and they usually inclose nearly perfect and very beautifully formed crystals of augite—sometimes of considerable size. But besides the scoriæ, showers of volcanic sand also fall around the observer standing beside the crater of Stromboli. This volcanic sand proves on examination to be, like the similar materials ejected from Mount Klut in Java in 1864, and from the volcano of Georg in the Gulf of Santorin in 1866, both of which were submitted to microscopical examination by Vogelsang, an aggregate of more or less broken and rubbed crystals of augite, felspar, olivine, and magnetite, with comminuted fragments of scoriæ.

Around the sides of the crater of Stromboli crystals of augite can be collected in great abundance; they are usually macled, and sometimes form beautiful stellar groups and other interesting combinations. These are doubtless in part ejected directly from the crater, but in other cases result from the breaking up of the light cindery fragments in the midst of which they were inclosed at the time of their ejection. That these crystals were actually formed *within* the volcanic vent there is not the smallest room for doubt.

That Stromboli has in comparatively recent times given forth streams of basaltic lava of very considerable magnitude is clear to any geologist who studies the fresh and undecomposed fields of lava

(Sciaras) which surround the island. Sometimes this lava assumes the finely columnar structure so common in rocks of this class. Thus, a very fine series of columns is exhibited at Punta Labronzo, the northern point of Stromboli, and ruder ones at Punta del Uomo, on the south-east of the island. On the extremest verge of this latter lava-stream is situated one of those little shrines, which, in spite of the apparent inaccessibility of its position, has its burning lamp constantly replenished. The voyager in these seas is startled when, on reaching these spots, the wild cries and strange songs of the boatmen are suddenly hushed, all engaging for a few moments in silent devotion to the saint who is supposed to warn, by means of this primitive and not very efficient lighthouse, the mariner who approaches these inhospitable shores.

The products of the modern eruptions along the *southern* line of fissure—that, namely, which extends beneath the islands of Lipari and Vulcano—offer, as we have already remarked, the most striking contrast to those of Stromboli. These lavas belong to that highly silicated class so well illustrated in the Ponza Islands, the Euganean Hills, and Hungary. The highly acid lavas, to which the name of quartz-trachyte is usually applied, but which by Roth were called "Liparite," and by Richtofen "Rhyolite," are in their ultimate composition almost identical with the granites; and when highly crystalline, are seen to be composed of precisely the same constituent minerals—namely, several species of felspar, orthoclase being always predominant, free quartz, and variable quantities of hornblende or mica. By the peculiar *arrangement* of their materials, however, the highly silicated lavas are well characterized; and in their internal structure they present features which almost always serve to distinguish them from the granites, with which they were by early geologists so frequently confounded.

In illustration of the ultimate composition of these highly acid lavas of Lipari, we give the following analyses of Abich, with which others by Berthier and Klaproth closely agree:

	Obsidian of Lipari.	Pumice of Lipari.
Silica	74·05	73·70
Alumina	12·97	12·27
Oxide of Iron	2·73	2·31
Lime...	0·12	0·65
Magnesia	0·28	0·29
Soda...	4·15	4·52
Potash	5·11	4·73
Water	0·22	1·22
Chlorine	0·31	0·31

The specific gravity of the obsidian is 2·3702, and of the pumice 2·3771. When in its most completely stony condition, the rock has a specific gravity of 2·53, and consists almost entirely of orthoclase felspar, quartz, and hornblende, in about the following proportions:

Felspar	77 per cent.
Quartz	18 „
Hornblende or Mica	5 „

In the less compact or stony and more cavernous varieties of

Liparite, the ordinary hornblende and mica crystals do not appear; but instead of them, we find in the mass grains of magnetite with groups of acicular, filiform, or capillary crystals, which we should at first sight refer to *Breislakite,* but which, considering their association, may probably be regarded as a variety of *hornblende,* bearing the same relation to the Amphibole series which Breislakite does to the Pyroxene series.

In striking contrast to the basic lavas of Stromboli, the highly acid lavas of the Lipari and Vulcano constantly tend to assume the vitreous condition; some of the lava-streams being, indeed, composed of solid volcanic glass. These glasses in turn frequently assume a more or less pumiceous structure, through the inflation of their materials with blisters and bubbles, as a consequence of the disengagement of those volatile constituents which the researches of many chemists show that obsidians so abundantly contain. The cones formed of the ejected fragments of these newer volcanos of Lipari and Vulcano consist of fragments of typical pumice. So excellent and abundant is the pumice of Campo Bianco in Lipari, that it is sent to all parts of the world; and its collection, preparation by drying, and exportation, constitute one of the most important sources of wealth to the islanders.

Mingled with the white pumice, which constitutes fragments of every conceivable size, there occur numerous volcanic bombs, in which every stage of the transition from obsidian to pumice can be admirably studied. The exterior surface of these bombs is covered with a crust of solid obsidian, which is usually cracked into a number of polygonal fragments; but, as we pass towards the centre of the bomb, blisters gradually increase in number, till the centre is found to be composed of a mass as light and porous as a sponge. Bombs of this character, sometimes many feet in diameter, and which have been usually broken by their fall, are found scattered around the active cone of Vulcano, and are in all probability the product of its last grand eruption in 1786.

The wonderful variety of the acid rocks of the Liparis arises from the fact that every possible gradation between the stony, vitreous, and pumiceous characters, may be observed in them. The liquefied material may, according to the conditions of its consolidation, assume one of three forms, Liparite, Obsidian, or Pumice, or it may form a material in which the diverse characters of these three products are united in the most singular and unexpected combinations.

Some of these remarkable and interesting varieties, which may be well studied at Rocche Rosse, Monte Perrara, Monte della Guardia, Fossa del Monte, Punta Capparo and many other points in Lipari, and in the great modern lava stream of Vulcano, it will be necessary briefly to notice.

First Series.—The most perfect glass is found passing by insensible gradations into rocks of less strikingly vitreous lustre—pitchstones or retinites—and thence through materials of pearly or porcellanous appearance into the most perfectly stony and crystalline, almost indeed granitic, masses. This series of changes is effected without the appearance in the mass of any definite arrangements of crystallites.[1]

Second Series.—Much more frequently, however, the passage from the vitreous to the stony series takes place by the appearance in the mass of scattered "sphærulites," composed of radiating crystals of felspar, entangling others of quartz, magnetite, and other minerals. Occasionally these sphærulites are found scattered in a promiscuous manner through the vitreous matrix; but, far oftener, they assume very striking and definite arrangements; these are clearly seen to be the result of the conditions of pressure, tension, and slow-dragging movements to which the slowly consolidating mass was subjected. Sometimes the alternate laminæ of vitreous or colloid and stony or crystallized materials have assumed a parallel arrangement, and the rock is almost as perfectly *cleaved* as a piece of slate; at others they assume all the beautiful wrinklings and corrugations so characteristic of metamorphic *foliated* schists. The light which these remarkable products throw upon the mode of formation of many of the older rocks will be illustrated on a future occasion.

Third Series.—At times the obsidian base of the rock is porphyritic, that is to say, it has crystals, often large and well formed, most commonly of brilliant sanidine, but not unfrequently of quartz, hornblende, or black-mica, floating through its mass. It then assumes the characters of an "obsidian-porphyry" (porphyritic obsidian). No one can study this rock, as exhibited in Lipari, without being convinced that the crystals which it contains were ejected, ready-formed, with the lava as it issued from the volcanic vent. Not only is there no trace of crystals in various stages of formation, as in the case of the sphærulites, etc., but sometimes pumiceous masses, evidently blown out of a volcanic vent, may be found entangling just such perfect crystals. We shall not at present enter on the discussion of those interesting problems which the phenomena of these perfect crystals of minerals of such different degrees of fusibility, floating in the same liquefied highly siliceous magma, must suggest to every geologist. We shall only notice, in this place, that the combinations of these ejected crystals with those gradually developed in the mass by the growth of crystallites, the whole modified by the peculiar mechanical conditions to which the masses have been subjected, result in the formation of rocks of wonderful diversity, exquisite beauty, and remarkable suggestiveness to the petrologist.

Fourth Series.—Fresh complexities of rock structure are originated and new varieties of lava produced, when, in either of the kinds already noticed, disengagement of volatile materials in the midst of the mass began to take place. The vesicular cavities thus originated were variously modified by the strains and movements to which the plastic mass was subjected. The most stony and highly crystalline, as well as the most vitreous varieties of these lavas, are thus affected

[1] The exceedingly beautiful and clear obsidian of Lipari, like that of Mexico, has been employed by the ancient inhabitants of the island for cutting instruments and weapons.

by the more or less complete disengagement of their volatile constituents; and while in the former, cavities originate which are occasionally lined with the most beautifully developed crystals of the component minerals of the rock,—in the latter, a laminated structure is produced, the planes of which sometimes coincide with, but not unfrequently cross, those produced by the devitrification of the mass under pressure.

But this attempt at a classification is far from exhausting the varieties of the beautiful quartz-trachytes of Lipari. New forms are originated through masses of obsidian being broken up and entangled in a stony matrix, or by glassy streams enveloping stony or perlite fragments, or, as is not unfrequently the case, by their catching up in their flow angular fragments of lavas of different composition, and belonging to earlier periods of eruption. Thus are originated the most singular brecciated structures, and rocks of very peculiar and, at first sight, puzzling character are produced.

When, however, these rocks are studied by the aid of the microscope, new features of interest continually make their appearance, only a very few of which it will be possible to notice in this place.

In the most clear and translucent volcanic glasses which have yet been examined, the beginnings of the process of *devitrification* can always be detected. Minute acicular crystals of felspar (Belonites) are seen, which, in a later stage of development, assume rectangular forms and ruin-like terminations, and thus gradually approximate to the ordinary characters of sanidine crystals. Other acicular or filiform crystals of hornblende (Trichites) appear and combine into radiating groups or tree-like masses of marvellous beauty. Where these crystals reach the surface of a cavity in the lava, free development of them often takes place, and we are enabled to study their nature and characters with the greatest facility.

Most frequently, however, the crystals unite in radiating masses, giving rise to those globular concretions known as *sphærulites*. In some cases the formation of these sphærulites has been determined by the liberation, in the midst of the vitreous mass, of an infinitesimal bubble of volatile matter. By the development of these crystalline globules with such exquisitely beautiful concentric and radiated internal structures, the peculiar forms and distinctive opalescent lustre of "perlite" is originated.

Nowhere, perhaps, can better materials be found for illustrating the development of these peculiarly interesting structures in vitreous rocks than in Lipari. Some of the pearlstones of this island, as, for instance, that of the lava-stream above Canneto, contain sphærulites of the size of peas. To attempt anything like an adequate account of the varieties assumed by the crystalline interiors and semi-vitreous envelopes of these, would require numerous figures and an amount of detailed description which would be out of place in these sketches.

It is in the northern part of Lipari that we find the best examples of the volcanic cones, craters, and lava-streams of the latest period of eruption in the Lipari Islands.

Supposing a furnace containing many millions of tons of liquefied glass were allowed to pour forth its contents in a stream extending to a length of some miles, and to a thickness of hundreds of feet, what would be the nature of the phenomena attending its outburst, and of the products which would result from its gradual solidification?

This is no idle problem; for the solution of it may be found by the geologist at Campo Bianco and Rocche Rosse.

Campo Bianco or Monte Pelato is a volcanic mountain (see Fig. 8), composed entirely of the whitest fragmentary pumice, the highest portion of the crater-ring of which rises to the height of more than 1500 feet above the sea-level. This is partially embraced (as is Vesuvius by Somma) by the relics of an older and far larger cone of the same materials, which culminates in Monte Chirien, having an elevation of nearly 2000 feet. The soft white pumice tuffs of the flanks of both these cones have suffered greatly from denuding forces, acting on their light and incoherent materials, and giving rise to those long furrows producing the "umbrella form" which is admirably exemplified in them. The crater of Campo Bianco presents at its bottom a flat plain, covered with comminuted pumice-tuffs, and now forming a most productive vineyard at a level of 892 feet above the sea; its walls rising almost vertically around it to heights of from 400 to 600 feet on the northern, western, and southern sides. On the north-eastern margin of this crater, however, a petrified cascade of vitreous lava rises 100 feet above the crater-floor, and, sweeping away all that side of crater-wall, has poured with a current, half a mile in breadth, down to the sea. This lava-stream, now covered with a reddish-brown coating from the oxidation of its iron, is the Rocche Rosse. Near the point where it issues from the crater, a deep "bocca" exists, once evidently the place of discharge of powerful steam-jets—now an awful pitfall, which the islanders avoid and speak of with terror. The surface of the lava presents a most striking example of those rugged cooled surfaces, like the *Cheires* of the Auvergne, and presents one of the wildest and most desolate scenes which it is possible to imagine. The traversing of it is in many places a very difficult task.

Other similar cones, craters, and lava-streams abound in Lipari. On the western side of Monte Chirien, at an elevation of more than 1700 feet, is a second crater, much ruined, that of the Piano dell' altra Pecora; and on the south side of Campo Bianco is another, that of Forgia Vecchia, or Monte Perrara, at an elevation of 968 feet, from which another stream of vitreous lava flows to the sea. At the head of this lava-stream no less than three mouths communicating with abysses of unknown depth, similar to that of the Rocche Rosse, are seen. They doubtless mark the sites of explosive discharges of steam. At Canneto is an older stream of perlite, which probably flowed before the present crater of Campo Bianco was formed.

The craters of the southern part of the island of Lipari give rise to lavas similar in composition to those of the north end of the island. In the former, however, the stony characters predominate

Fig. 8.—View of the breached crater of Campo Bianco, with the lava-stream of Rocche Rosse, seen from the sea.

⋎ Monte Pelato; ⋎⋎ Monte Chirien; ⋎⋎⋎ Monte Sant'Angelo; ⋎⋎⋎⋎ Monte di Tre Pecore (in the distance).

over the glassy, while in the latter the reverse is the case. Old craters can be traced at Fossa del Monte, Monte della Guardia, and other points in the district.

Some of these lavas have undergone a certain amount of alteration from the passage through them of acid gases, as is shown by the following analysis by Abich of a Liparite from Monte della Guardia:

Silica	68·35
Alumina	13·92
Oxide of Iron	2·28
Lime	0·84
Magnesia	2·20
Potash	3·24
Soda	4·29
Volatile materials, principally Sulphur and Sulphuric Acid	4·64

While the action of the acid gases upon the *ordinary trachytes* of the second period of eruption in Lipari gives rise to the formation of selenite and basic sulphates of iron,—sulphate of alumina and free sulphur are the products of the same action on the later formed *quartz-trachytes.*

To those who regard the fluidity of lava as the result of simple fusion, nothing can be more startling than the behaviour of these obsidian currents of Lipari. While, as is well known, some of the highly crystalline lavas of Vesuvius have flowed with the most astonishing rapidity, these glassy masses have evidently possessed only the most imperfect fluidity. In proof of their viscosity I may point to the manner in which the modern obsidian stream of Vulcano is confined to the steep slope of the cone, at the bottom of which it has piled itself up in great hummocky masses, instead of spreading out in a fan-shaped manner, or continuing to flow in a stream over the smaller slopes. The same fact is more or less strikingly illustrated by all the glassy lava-streams. But even more decisive evidence of this slow movement of the obsidian lavas, and of the vast amount of tension and pressure to which their masses have been subjected, is afforded by their *internal structure.* Every conceivable condition of plication, crumpling and puckering, is illustrated by the sections afforded either in sea-cliffs or the ravines cut by mountain torrents in these obsidian lavas. The appearance presented at two different portions of the same lava-streams, as exposed in a steep escarpment at Porto delle Genti, south of the city of Lipari, are shown in Fig. 9: in A the mass has been bent into large but sharp folds; in B the folding has been accompanied by the most intense crumpling and puckering. As we shall show on a future occasion, these mechanical forces have combined with the forces producing devitrification to produce some most interesting phenomena in the minute internal structure of the rocks.

There can be little doubt that the last great effort of volcanic activity in the island of Lipari was that which produced the present crater of Campo Bianco, and the lava-stream of Rocche Rosse. In spite of traditions and obscure historical allusions, I find it difficult to believe, so much have the hard masses of lava suffered in places both from marine and subaerial denudation, that any record of this great eruption can have survived.

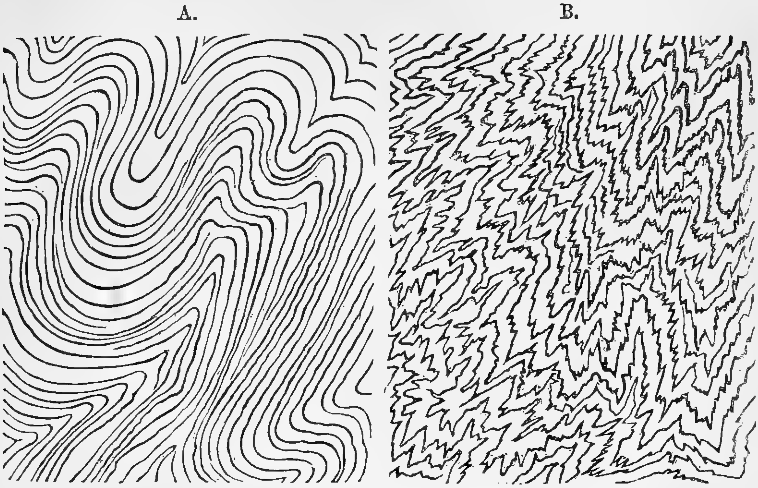


FIG. 9.—Sections of quartz-trachyte (Liparite) lava-streams at Porto delle Genti, illustrating the folding and crumpling of their interior portions, produced by the slow movement of the viscous mass. A. Exhibits a series of broad folds. B. A series of most complicated puckerings, exactly like that seen in many gneissose rocks.

To their permeation by gases and vapours, probably during the latest period of eruption, the altered trachytes and tuffs, with their veins of selenite and other minerals, are probably due. Only two vents, constituting the dying efforts of volcanic activity, once so powerful in this island, still remain, being situated on its western side; one of these is at Bagno, or la Fonte di San Calogero, and gives rise to a hot mineral spring; the other is at Bagno Secco, a little to the northward, and only dry stream, charged with hydrochloric and sulphurous acid gases, is evolved from it.

The hot spring of San Calogero has long been celebrated for its curative properties, having been mentioned by Diodorus Siculus; in 1870 a bath-house and hotel were erected here by the municipality of Lipari. In a medical tract by Dr. Guiseppe Eincotta, the use of these waters in various rheumatic and cutaneous affections is stated to be attended with the most beneficial results.

The water, which has a temperature of 198° F., that of the surrounding atmosphere being 77°, has been analyzed by Dr. Ferdinando Rodriguez, and also by Prof. Guiseppe Arrosto, of the University of Messina. It contains free carbonic acid and sulphuretted hydrogen, with the carbonates of lime and magnesia, and chlorides of calcium and sodium, and a little organic matter.

The following is the result of Prof. Arrosto's analysis:

Oxygen	0·0037
Nitrogen	0·0126
Carbonic Acid	0·2758
Sulphuric Acid	1·8842
Silicic Acid...	0·0082
Chlorine	3·8630
Lime	0·5286
Magnesia	0·3219
Potash...	0·1092
Soda	2·7629
Iron, Organic substances, and Alumina ...	traces.
Total solid and gaseous substances	9·7701
Water	990·2299
Total	1000·0000

The water deposits upon the walls and pipes of the bath-house a thick white incrustation.

Of the more active and very striking manifestations of volcanic activity at the present time in the Lipari Islands we shall treat in succeeding chapters, which we propose to devote to the description of the remarkable active volcanos of Vulcano and Stromboli.

(To be continued in our next Number.)

III.—A Chapter in the History of Meteorites.

By Walter Flight, D.Sc., F.G.S.,

Of the Department of Mineralogy, British Museum;
Assistant Examiner in Chemistry, University of London.

(*Continued from page* 30.)

1870, January 23rd.—Nidigullam, near Parvatypore, Vizagapatam District, Madras. [Lat. 18° 41′ 20″ N.; Long. 83° 28′ 30″ E.] [1]

A meteoric iron, weighing 407 tolas (about 10 lbs.), fell at Nidigullam, and penetrated the ground to the depth of twenty inches. Those who saw the meteor describe it as very large and beautiful, and as exhibiting increased brilliance when it burst. The explosion was followed by a series of rumbling noises. The meteorite passed over Parvatypore from N. to S.; the people of the village were greatly alarmed, and one man, near whom it fell, was stunned. The villagers "carried it off to their temple, and, much alarmed, were found making púja to it." The author of the notice in the *Proceedings* considers that this aerolite contains no stony matter, and he states that it is marked with striæ lying obliquely to its greatest length, which is 6½ inches. The lamented Dr. Stoliczka, however, was of opinion, from the description of the striation, that it is a stone containing much iron, "like the Mooltan aerolite which fell some short time ago."[2] If it be metallic throughout, as Saxton asserts, it is the third[3] iron recorded to have fallen in India, and one of the very few

[1] G. H. Saxton. *Proc. Asiat. Soc. Bengal,* 1870, 64.—This fall is stated by Mr. Greg, in the *Report Brit. Assoc.*, 1870, to have taken place December 26th, 1869.

[2] This is probably the meteorite of Lodran which fell 1st October, 1868 (see Part II.).

[3] The second is that found at Prambanan, Soerakarta, Java, in 1865; if we include

the descent of which has been witnessed. Among these very few is the iron of Jullunder (Jálandher), Lahore, the history of which has quite recently been studied by H. Blochmann.[1] According to the Iqbálnámah i Jahángírí, a dreadful explosion was heard in a village near Jullunder on the morning of the 10th April, 1621 (old style),[2] and "a lightning-like lustre shot along the heaven and descended to the earth, and disappeared." Muhammad Sa'íd, the Collector of Jullunder, rode to the spot, and ordered the burnt ground where the meteor struck to be dug. The deeper his men dug the hotter and crisper the ground became "till they alighted on a lump of iron, which was so hot that it seemed to have come that very moment out of the oven. His Majesty (Jahángír) sent for Ustád Dáúd, who was well-known in those days for the excellent sword-blades that he made, and ordered him to make the lump into a sword, a dagger, and a knife; but the iron would not stand the hammer, and crumbled to pieces."[3] He mixed the meteoric iron (*ahan i barg*, lightning iron) with common iron, and forged the weapons. This meteorite is calculated to have weighed 5·27 lbs. Troy.

1870, June 17th, 2 p.m.—Ibbenbühren, Westphalia.[4]

This stone was seen to fall. It is stated that a flash of light was succeeded in about one minute by a noise as of thunder, which attracted the attention of many persons within a radius of some three miles, and three minutes later the stone was seen to fall by a peasant distant some hundred paces. It entered the ground to the depth of 0·7 metre in a well-trodden footpath; a fragment (30 grammes) was afterwards found 300 to 400 paces from the spot. The meteorite, which weighs 2·034 kilog. and is almost perfect, has the form of a flattened spheroid; and the black crust, which is somewhat less than 0·1 mm. thick, bears on its surface a great number of very minute 'ridges of fusion' that are less marked than in the aerolites of Stannern and Pultusk. On the posterior portion of the stone the fused matter has streamed along the surface. The stone, moreover, exhibits curious depressions, resembling the marks which are made by fingers on a plastic mass.

The body of the stone is of a remarkably light colour, and consists of a greyish-white granular mass, through which are very unequally distributed numerous large and small grains of a light yellowish-green mineral. Some attain a size of 3 mm., and all that were examined were so deficient in crystal-faces, and even in cleavage-planes, that an accurate determination of their form could not be made; judging from the cleavage, however, this mineral appears to

under the word 'India' not only the British possessions, but the foreign settlements in the Indian Archipelago.

[1] H. Blochmann, *Proc. Asiat. Soc. Bengal*, 1869, 167.

[2] This fall, in Mr. Greg's Catalogue, bears the date April 17th, 1620.

[3] Compare with Mallet's experiments in forging the meteoric iron of Augusta County. (See page 28).

[4] G. Vom Rath. *Monatsber. Ak. Wiss. Berlin*, 1872, 27; *Pogg. Ann.*, cxlvi. 474.

be rhombic. It has a specific gravity of 3·42 and the following composition:

			Oxygen.	
Silicic acid	54·51	...	29·07	
Iron protoxide	17·53	...	3·89	14·82
Manganese protoxide ...	0·29	...	0·06	
Magnesia	26·43	...	10·57	
Lime	1·04	...	0·30	
Alumina	1·26	...	0·59	
	101·06			

or that of a bronzite of the form $(\frac{2}{7}FeO\frac{5}{7}MgO)SiO_2$.

The pale grey very friable interstitial matter, freed as thoroughly as possible from the grains of bronzite, was next examined. The specific gravity is 3·40, and the mean composition of two analyses is as follows:

			Oxygen.	
Silicic acid	54·47	...	29·05	
Iron protoxide	17·15	...	3·81	14·72
Manganese protoxide ...	0·28	...	0·06	
Magnesia	26·12	..	10·45	
Lime	1·39	...	0·40	
Alumina	1·06	...	0·50	
	100·47			

It is seen, then, that the interstitial mineral and the grains have the same composition, and that the constitution of the Ibbenbühren meteorite is one of the simplest of any meteorite yet investigated. It not only consists essentially of a single silicate, but contains neither chromite, magnetic pyrites, nor sulphur compound of any kind. A trace of metallic iron was met with, and some reddish-yellow grains with a brilliant surface, which have not been examined. Can they be the curious mineral found in the stone of Busti, which appears to be a compound of zirconium (or titanium), calcium, and sulphur? The black crust is strongly magnetic, some of the iron protoxide of the bronzite having been converted during the passage of the stone through the atmosphere into the higher and magnetic oxide.

While this meteorite very nearly resembles that of Manegaum, it approaches still more closely in composition to the bronzite of the Shalka stone. It will be remarked that the meteoric bronzites far exceed terrestrial bronzites as regards their per-centage of iron oxide.

We now know four aerolites consisting of a single silicate:

Chassigny (1815, October 3rd)	Olivine.
Bishopville (1843, March 25th)	Enstatite.
Manegaum (1843, June 29th)...	Bronzite.
Ibbenbühren (1870, 17th June)	

Vom Rath's paper is illustrated with a drawing of the stone.

In a short supplement in *Poggendorff's Annalen* is given a brief description of a microscopic section of this stone, prepared by Buchner, of Giessen. The entire slice is seen to be made up of rounded bronzite grains, without any heterogeneous ground mass uniting them. By rotating the Nicols the most brilliant play of colours is observed, the entire stone presenting crystalline characters. Little clefts filled with fused material cross the field in every direction. Two very small red granules were observed in the bronzite; their composition is not known. Similar bright coloured grains have been met with in meteorites by Wöhler and other observers.

1870, October 27th, 3 a.m.—Forest, Ohio. [Lat. 40° 50′ N.; Long. 84° 40′ W.][1]

The meteor exploded with a report like that of a heavy siege gun, followed by two or three reports in rapid succession. The firmest houses were shaken to the foundations, and thousands of sleepers aroused in an instant. People awake at the time were startled to see the night suddenly lighted into day and again relapse in darkness. The time between the extinction of the light and the sound of the explosion is estimated at from one minute to half a minute. An observer at Patterson, a mile from Forest, states that the meteor came from the direction S. 35° W. The descriptions of its size are of the usual vague kind: one man makes it as large as a beer-keg, another as a load of hay, while a third observed a tail thirty feet long and three feet wide!

The report appears to have been heard for fifty miles around, if not at still greater distances. No fragments of the meteorite have been found.

Found 1870.—Kokomo, Howard Co., Indiana.[2]

A piece of meteoric iron was found in plastic clay under a bed of peat. It is described as a flattened, irregularly-shaped mass, rounded on one side and concave on the other. It is 5 inches long, $3\frac{1}{2}$ inches wide, and $1\frac{7}{10}$ inches thick; and it weighs 4 lbs. $1\frac{1}{2}$ oz. It is granular, like fine steel, and is malleable; and though harder than common iron, can be wrought into any form. No quantitative analysis of this iron has yet been made, but the presence in it of the following elements has been determined: nickel, cobalt, tin, carbon, phosphorus, and perhaps sulphur. By acid the Widmannstättian figures are developed in great perfection.

Found 1870.—Ilimaë, Desert of Atacama, Chili. [Lat. 26° S.; Long. 70° W.][3]

This, the most recent addition to the little group of irons and siderolites which have from time to time been found on the desert and cordilleras of Atacama, in about the latitude of the Tropic of Capricorn, partly in Chili and partly in Bolivia, was acquired for the Vienna Collection in 1870. It is a very interesting specimen of meteoric iron, apparently nearly complete, and weighing about 51 kilog. It bears a rough resemblance to a shield, being convex on one side, somewhat hollow on the other.

Over the entire concave side are shallow hollows from 3 to 4 cm.

1 J. L. Smith. *Amer. Jour. Sc.*, 1870, xlix. 139.
2 E. T. Cox. *Amer. Jour. Sc.*, 1873, v. 155.
3 G. Tschermak. *Denkschrift Wien. Akad. Math. Naturw. Classe*, xxxi. 187.—E. Ludwig. *Sitz. Wien. Akad.*, lxiii. 323.

in breadth, and these in turn are marked with smaller hollows. The whole surface is also covered with three systems of fine parallel lines, forming a network; two of these are at once apparent, the third only after careful inspection: they are Widmannstättian figures developed by the natural oxidation of the surface. The positions of the blunted edges between the shallow cavities are seen to be closely connected with the course of these traversing lines, and the entire meteorite is, as regards its crystallographic characters, formed alike throughout.

The second side exhibits sharper ridges and a greater number of the smaller hollows, which are only one-fourth or one-third the size of those on the concave surface, and have much steeper sides. Here also is seen the network of lines, still more distinct, and traversing corresponding directions. Two systems intersect at an angle of about 70°; the third, which is only occasionally visible, forms equal angles with the other two. If these lines be sketched, as has been done by Tschermak in his memoir, it becomes apparent that they correspond with a 110 face (rhombic dodecahedral face) on meteoric iron, which in the Widmannstättian figure is an isosceles triangle, with the angle of the apex equal to 70° 32′. The lines or lamellæ forming the equal sides of the triangle are perpendicular to the 110 face, while the lamellæ of the third system form with the 110 face, angles of 35° 16′ and 144° 44′. It thus becomes clear why it is that the lines inclined to each other at an angle of 70° stand out so distinctly, while the others are less readily detected: the former meets the cut surface perpendicularly, the latter at a comparatively slight inclination.

The original surface is gone, but it was probably pitted, and the iron presents the appearance of having at one period formed portion of a larger mass. In the different characters of the hollows on the two sides, it bears a general resemblance to the Agram iron, on which von Widmannstätten in 1808 first developed the figures that bear his name.

This aerolite, mineralogically considered, contains: iron; nickel-iron; schreibersite; and troilite.

The iron occurs in three distinct forms: as beam-iron (*Balkeneisen*); as tänite or fillet-iron (*Bandeisen*); and as interstitial iron (*Fülleisen*).[1]

The beam-iron is seen on an etched surface in the form of long stripes, which often extend right across it; they are 1 mm. and sometimes 2 mm. in breadth, and occupy the greater part of the surface, traversing it in three directions. One of these intersects a second at an angle of about 83°, and the third at about 97°. If the cut surface were parallel to a cubic face, only two of these directions would be seen, and they would intersect at an angle of 90°. The face of the section, however, happens to lie somewhat out of the plane of the (100) face, and is nearly parallel to the face of a leucitoid (811), for which face the angles of the trapeze, in Tschermak's drawing, are 82° 59′ and 97° 1′.

[1] Von Reichenbach distinguished four varieties of iron developed by etching: Balkeneisen, or kamacite; Bandeisen, or tänite; Fülleisen, or plessite; and Glanzeisen, or lamprite (*Pogg. Ann.*, cxiv. 99).

If etched, the beam-iron takes a set lustre, which Haidinger termed crystalline damaskining. Each stripe, when viewed in particular directions, exhibits a sheen, in intervening directions appearing dull; all stripes have not the same orientation of the lustre, a group, irregularly distributed, always shining forth at the same moment. A single stripe of this form of iron, if only slightly etched, exhibits, under the microscope, very fine etched figures of two kinds: fine threads 0·01 mm. broad, which are straight along one side and serrated on the other; they have the same habit and traverse the same directions as the etched lines that were first observed in the Braunau iron.[1] These threads are the sections of lamellæ which are inclosed in definite crystallographic orientation in the beam-iron. When one of them meets a plate of tänite, the former is as a rule terminated, not unfrequently to be continued in the next stripe of beam-iron; some, however, which meet a fillet of tänite at an angle of about 70°, are seen to pass through the last-mentioned mineral. The other appearance, developed by slightly etching the beam-iron, consists of small oblong areas with fine hatching. Seen in favourable light, all the parallel sunken lines shine out along one slope; and if the plate be rotated through 180°, they light up again along the other; in intervening positions they appear dull. These brighter areas are often in parallel position, though not invariably so; if, however, the angles be measured which they make with the fillets of tänite and with the cubic lamellæ, it is observed that in point of relative position they exactly accord with the etched lines on the Braunau iron. They never penetrate the plates of tänite. When the corroding action of the acid is prolonged, these appearances are destroyed, and are replaced by etched lines and etched cavities.

The etched lines have the same characters as those of the Braunau iron, but they are shorter and more difficult to measure. The section, as stated, is not exactly parallel to the face 811, so that the following determinations of some of the angles which the etched lines make with lines parallel to 100 are only approximate:

Observed.	Calculated for 100	Calculated for 811
27°	26° 34′	25° 7′
63°	63° 26′	64° 7′
86°	82° 53′	85° 40′
109°	104° 2′	110° 47′
119°	119° 45′	117° 49′

while the angles which the etched lines form with lines parallel to 111 are:

Observed.	Calculated for 100	Calculated for 811
23°	30° 58′	23° 51′
45°	45° 0′	45° 24′
53°	52° 7′	48° 58′
69°	71° 34′	70° 30′

These observations place beyond doubt the fact that the deeper lines thus brought out are the usual lines of etching.

[1] J. G. Neumann. *Aus der Naturwiss. Abhandl.* (*W. Haidinger*), iii. Ab. 2, 45.

The cavities, produced by the action of acid, are very small, about 0·005 mm. across, and have a rounded, sometimes quadratic, outline; the more perfect having the form of rounded cubes. They are most abundantly met with on the fillets alluded to above, those in the same piece of beam-iron being similarly orientated, and it is to them and the parallel serration of the fillets that the crystalline damaskining is due.

In the beam-iron are inclosed schreibersite and troilite, but graphite was not observed. The schreibersite is only met with in this form of iron, and occurs there in rounded particles and elongated forms, which proceed from plates of this mineral, many of which lie parallel to an octahedral face. It occurs very frequently round about the remarkable lamellæ of troilite (see *infra*) that lie parallel to the faces of the cube.

The fillet-iron (*Bandeisen*), or tänite, presents itself on the etched surface in the form of prominent bands or fillets between the stripes of beam-iron, and they are sections of lamellæ lying parallel to those of the beam-iron,—in other words, to the octahedral faces. This form of iron, though in such thin plates, is found by the microscope to be a fine tissue of heterogeneous substances. One of these is nickel-iron, which coats the lamellæ of tänite. A section of this mineral is dull in appearance, but the boundary is brilliant; while outside it, lie brilliant points of not unfrequently regular form. The framework and the points have the yellowish colour of nickel-iron. The duller field, when strongly magnified, is seen to consist of exceedingly fine plates of nickel-iron, which lie in two different directions, for the lines intersect at 90°. The material lying between these plates, which has been removed in greater abundance, is pure iron. The lamellæ of tänite are often penetrated and traversed by fine plates of beam-iron.

The interstitial iron (*Fülleisen*), which, as the name implies, occupies the areas between the minerals already mentioned, is abundantly present in masses sometimes extending to the breadth of 1 cm. It is made up of tänite and beam-iron, and is a representation of the structure of the entire meteorite on a smaller scale, with such modifications as seem to indicate that after the large lamellæ of beam-iron and tänite were already formed, the matter inclosed between them became solid, and, shaping itself in accordance with the same laws in a limited area, produced this variety of meteoric iron. It occurs in two forms that vary but little from each other. In one, fine stripes of beam-iron intersect, while between them is tänite: this is an exact reproduction of the coarser structure of the meteorite. In the other (and this is observed in the larger masses) the square form is provided along its boundary with stripes of beam-iron, the remainder appearing granular through a number of little particles of beam-iron being ranged together with nickel-iron between them.

The occurrence of troilite in lamellæ has been observed for the first time in this iron. They lie parallel to the cubic faces, and, unlike those of tänite, do not traverse any considerable portion of the etched surface. The largest are 3·5 cm. long and 1·5 wide, and have a thickness of from 0·1 to 0·2 mm. They have a sharp outline, homogeneous structure, and are easily recognized as consisting of the brittle bronze-coloured sulphide which decomposes with acid. These lamellæ are covered on either side with a layer of beam-iron, which separates them from the tänite, the interstitial iron, and the lamellæ of beam-iron that are parallel to the octahedron; whenever one of the last-mentioned plates happens to be situated near a lamella of troilite, it will be found that the troilite has broken through it.

The troilite seems to have been formed first. After it had become covered with a layer of beam-iron, the octahedral lamellæ (the tänite and the beam-iron) appear to have been developed; and last of all the interstitial mass, likewise in accordance with the law which governed the formation of the octahedral lamellæ.

The troilite of this iron occurs almost entirely as cubic lamellæ, but rarely in the familiar nodular form. On examining the irons of the Vienna Collection, Tschermak discovered thin plates of troilite, covered, as above, with beam-iron, in the meteorite of Jewell Hill, Madison Co., North Carolina, found in 1856. The lamellæ are just as abundant, have the same orientation as those of the South American iron, and are about one-third the size.

These two irons differ but slightly in composition:

	Atacama.	Jewell Hill.
Iron	91·53	91·12
Nickel	7·14	7·82
Cobalt	0·41	0·43
Copper	trace.	trace.
Phosphorus ...	0·44	0·08
	99·52	99·45

The paper is illustrated by four beautifully executed plates; two showing the markings on the surface of the mass, the other two the figures developed by etching a section.[1]

[1] The following meteoric irons and siderolites from this region, several of which probably belong to one fall, have now been recorded; the greater number are preserved in some well-known collection, and have been submitted to examination.

(1). 1827. *Siderolite* (Brit. Mus. Coll.). Atacama, Bolivia.—Reported on by Bollaert (*Journ. Royal Geogr. Soc.*, xxi. 127); and by Reid (*Chambers' Jour.*, March 8, 1851), who places the locality in lat. 23° 30′ S. and 45 to 50 leagues from the coast. According to R. A. Philippi (*Jahr. Min.*, 1855, 1), masses weighing 120 to 150 lbs. were found one league from Imilac, in the centre of the Atacama Desert. Imilac is 35 leagues from the coast, 40 leagues from Cobija, and 35 from Atacama. Rose places the locality in Chili. (In Stieler's Atlas, Atacama Mt. is in Bolivia; the Desert of Atacama, partly in Chili, partly in Bolivia; the Province of Atacama, in Chili; and Atacama Alta in Bolivia.) This will be the meteorite analyzed by Frapolli, and described by Bunsen in 1856, the metallic portion of which contains:

$$Fe=88{\cdot}01;\ Ni=10{\cdot}25;\ Co=0{\cdot}70;\ Mg=0{\cdot}22;\ Ca=0{\cdot}13;\ Na=0{\cdot}21;\ K=0{\cdot}15;\ P=0{\cdot}33\quad =100{\cdot}00.$$

(2). 1858. *Iron* (Brit. Mus. Coll.). Atacama, Bolivia.

(3). 1862. *Siderolite* (Brit. Mus. Coll.). Sierra de Chaco, Desert of Atacama.—Rose places this in Chili, and the position of Chaco is stated to be lat. 25° 20′ S. and long. 69° 20′ W.; he (*Ber. Berlin Akad.*, 1863, 30) could not develope etched figures

Found 1870.—Iquique, Peru.[1]

This mass of iron was discovered on a mountain slope on the western border of the pampa of Tamarugul, ten leagues east of the harbour of Iquique. It lay at a depth of from two to four feet below the surface, being imbedded partly in a bed of nitre, of the hardness of stone, partly in the overlying soil. When found, the metal was so hard that two chisels were broken in an attempt to remove a fragment of it. A piece that had been heated became malleable, and was beaten into very thin plates.

The Iquique iron has the form of a plate, 6 cm. in thickness; on one side it is convex, somewhat bent inwards on the other, with a

on the nickel-iron, which had the composition: Fe = 88·55; Ni = 11·5; the meteorite resembles that found at Hainholz some years earlier.

(4). 1863. *Siderolite* (Brit. Mus. Coll.). Copiapo, Chili.—In the *Amer. Jour. Sc.* (1864) xxxvii. 243, C. A. Joy describes a siderolite from the Janacero Pass, 50 English miles from Copiapo, Province of Atacama, Chili. The spec. gravity of his specimen is 4·35, and it was composed of nickel-iron, troilite, and silicates. J. L. Smith (*Amer. Jour. Sc.*, xxxviii. 386) considers it to be identical with the Sierra di Chaco meteorite described by Rose (see No. 3). Captain Gilliss, of the United States Observatory at Washington, believes 'Janacera' may be a misprint for 'Jarquera,' the name of a river which rises in one of the Atacama passes.

(5). (No date). *Siderolite* (Brit. Mus. Coll.). Atacama, Bolivia.

(6). 1866. *Iron* (Brit. Mus. Coll.). Cordilleras of Atacama, Chili.—M. Daubrée (*Compt. rend.*, lxxvi. 569) describes a large iron, weighing 104 kilog., acquired in 1867 for the Paris Collection. It was found in November, 1866, on the west slope of the high cordillera of the Andes, between the Rio Juncal and the Salt-works of Pedernal, 50 leagues N.E. of Paypote. (The difficulty of transporting heavy masses across such an arid region is very great; according to Dr. Phillippi (*The Times*, August 31st, 1874), it only rains about once in from 20 to 50 years.) This mass bears on the surface the systems of lines which Tschermak observed on the Ilimaë iron, and Damour finds them agree in composition. They are probably all members of the same aerolitic fall.

(7). (No date). *Iron* (Brit. Mus. Coll.). Sierra di Deesa, Chili.—Under this name M. Daubrée has given (*Compt. rend.*, lxxvi. 571) a description of a brecciated iron from the cordillera of Deesa, near Santiago, acquired in 1867. It closely resembles the iron found in 1840 at Hemalga, in the Desert of Talcahuayo, in Chili. It contains 2·4 per cent. of silicate, which has been chemically examined by Meunier. (*Sitz. Wien Ak.*, lxi.).

(8). 1866. *Iron* (Brit. Mus. Coll.). Juncal, Cordilleras of Atacama, Chili.

(9). 1864. *Siderolite* (Berlin Coll.). Atacama, 50 miles from Copiapo.—It appears probable from the rough description of the locality that this may be the same meteorite as the one mentioned under No. 4, although the dates do not correspond. In that case J. L. Smith's view of the identity in character of the meteorites will have to be extended to Nos. 3, 4, and 9.

(10). 1870. *Iron* (Vienna Coll.). Ilimaë, Desert of Atacama, Chili.

(11). (No date). *Siderolite.* Taltal, Desert of Atacama.—J. Domeyko (*Compt. rend.*, lviii. 551) describes some masses of considerable size on the high plateau of the Desert near the copper mine of Taltal, south of Imilac. The spec. gravity of a fragment was 5·64.

(12). 1863. *Siderolite* (Vienna Coll.). Copiapo, Chili.—Described by Haidinger (*Sitz. Wien Akad.*, xlix. 499), as a coarsely granular brecciated meteorite. The nickel-iron, according to Von Hauer, consists of: Fe = 93; Ni = 6·4.

(13). 1859. *Iron?* Toconado, Desert of Atacama.—J. J. von Tschudi, writing under the above date to Haidinger (*Sitz. Wien Akad.*, xlix. 494), mentions a meteoric mass, weighing 80 arobas (20 cwt.), which lies 20 leagues N.E. of Toconado. He states that it agrees in structure and appearance with the Atacama iron lying 50 leagues southward.

[1] G. Rose. Abdruck aus der Festschrift der Gesell. Naturforsch. Freunde zu Berlin, 33, Berlin: Dümmler, 1873.

deep cavity on one part of the surface. The former is covered with ridges, running obliquely across its side, and in most cases parallel to each other. The weight of this block of metal is 21 lbs., and the specific gravity 7·925. When cut, it takes a fine polish, and exhibits strong metallic lustre and a steel-grey colour. Four analyses have been made, three by A. Raimondi, of Lima, and one by Rammelsberg, that last quoted, with the following results:

	I.	II.	III.	IV.
Iron	81·42	85·61	87·59	81·66
Nickel	18·51	14·37	12·38	15·49
Cobalt	...	...	...	0·19
Insoluble portion ...	...	...	...	2·66
	99·93	99·98	99·97	100·00

The insoluble constituents were: iron 2·17; nickel 0·37; phosphorus 0·05; and a residue, that withstood the action of hydrochloric acid, 0·07.

The attention of the reader will be taken by the unusually large per-centage of nickel present in this meteorite, it being as high as, or higher than, that of the aerolite of Shingle Springs (see page 28). We saw that the American iron, and the one from the Cape of Good Hope, found at the end of last century, resembled each other not only in the quantity of nickel in the alloy, but in the fact that neither of them developed figures when etched. The Peruvian iron forms a third example of this class, for it also shows no Widmannstättian figures: by treatment with acid it takes a pale grey colour, and is dull. In lieu, however, eight fine straight parallel stripes, singularly unlike any markings usually observed, are seen to traverse the etched surface, nearly directly across the greatest length of the block. Four of these crossing near the middle of the surface appear to be equidistant from each other, like lines on ruled paper; the remaining four lie in pairs, one on the right, the other to the left of the group of four, the whole number, as stated, being in parallel position. The spaces between the members of the first pair and of the other pair respectively exhibit for some distance the same lighter surface that gives prominence to the stripes themselves. These stripes do not appear to be in any way connected with the ridges on the outer surface, and though evidently brighter than the face generally when seen in certain directions, are duller than it when viewed in others. Very similar stripes were noticed on the Cape iron[1] already mentioned; in fact, till Rose made his observations, it was the only iron which was known to exhibit such phenomena. As to their cause, the author did not advance any explanation beyond attributing them to the position of the small particles composing the stripe. They present some of the characteristics of the plates of beam-iron observed in the Atacama and many other irons.

This iron apparently contains no sulphur, and the sections of little inclosed crystals, such as those met with in the Cape iron, which

[1] G. Rose. *Aus Abhandl. Berl. Akad. Wiss.*, 1863-70.—E. H. von Baumhauer. *Archiv. Néerland. des Sciences Exactes et Natur.*, ii. 377.

Baumhauer believed to be of pyrites (FeS_2), but which Rose maintained were of magnetic pyrites, were in vain sought for.

Two plates, copied from photographs of the aerolite, are appended to the paper.

It rarely happens that Widmannstättian figures are developed in irons containing more than nine per cent of nickel. With a knowledge of the difficulties attending the complete separation of nickel and cobalt from iron and of the different action of the re-agents, employed to bring these metals into solution, on the phosphides, rich in nickel, which frequently accompany them, it would not be advisable to lay too great stress on the results of earlier analyses of meteoric irons as pointing to any general conclusion when the details of the processes made use of cannot likewise be studied. It is worthy of note, however, that the irons mentioned below, with the per-centage of nickel found in them, give lines occasionally, but no figures:

Octibbeha Co. = 59·69; Caille = 17·37; Babb's Mill = 17·1, 14·7, and 12·4; Howard Co. (1862) = 12·29; Atacama (1862) = 11·5; Krasnojarsk = 10·73; Tucuman = 10·0; Zacatecas = 9·89; and Szlanicza = 8·91.

While the following irons exhibit them in great perfection:

Elbogen = 8·5; Lion River = 6·7; Lenarto = 6·55; Modoc = 6·35; Sevier Co. = 6·5 and 5·8; Schwetz = 5·77; Tabarz = 5·69; Cambria = 5·7 and 5·0; Braunau = 5·5; Asheville = 5·0; and Ruff's Mountain = 3·12.

(To be continued in our next Number.)

IV.—On the Post-pliocene Formations of the Isle of Man.

By J. A. Birds, B.A.

It is not a little remarkable that, while almost every part of England and Scotland, and particularly the district of "the Lakes" and North Wales, has been abundantly studied and written about,—and while Ireland also has been almost completely surveyed,—the Isle of Man should not only have been left untouched by the Geological Survey, but, latterly at least, should have well-nigh escaped the attention of geologists altogether. With the exception of three or four papers by the Rev. J. G. Cumming, published in the Quarterly Journal of the Geological Society, and their embodiment in a more popular form in his History of the Isle of Man, and Guide Book,[1] scarcely anything appears to have been written

[1] The following is as complete a list as I have been able to glean of all works or papers relating to the geology of the Isle of Man:—

1. "An Account of the Isle of Man." By Geo. Wood. 1811.
2. "A Mineralogical Account of the Isle of Man" By Dr. Berger. Transactions of the Geological Society, 1st series, vol. ii. 1814.
3. "A Supplementary Notice of the same." By Prof. Henslow. Trans. of the Geol. Soc. 1st series, vol. v.
4. A Notice of the Island in Macculloch's "Western Isles of Scotland," vol. ii. p. 516. 1819.
5. "A Memoir on the Discovery of the *Megacaros Hibernicus* in the Isle of Man." By Dr. Hibbert. Edinburgh Journal of Science, No. 5. 1826.
6. "On the Stratification of Alluvial Deposits in the Isle of Man." A Pamphlet by H. R. Oswald, Esq. Douglas, 1823.
7. "On Concretions in the Pleistocene Deposits of the North of the Island." By Hugh Strickland, Esq., F.G.S. Proc. Geol. Soc. vol. iv. 1843.

upon the geology of the island, besides some Memoirs published in the infancy of the science, or a few brief notices of special points since.

Mr. Cumming, who for many years was Vice-Principal of King William's College, Castletown, appears to have studied the geology of the little country very thoroughly, and has left an excellent account of it, illustrated with several maps and sections. Probably the Geological Surveyors, when they come to explore the island, will find little to correct or add to in the portion of Mr. Cumming's works which relates to the older rocks—unless it be to determine positively the age of the Silurian schists.

With regard, however, to the later, or Post-pliocene accumulations, the progress made in this portion of geology since the publication of Mr. Cumming's "History" in 1848, will, I think, necessitate very considerable changes.

Mr. Cumming divided these formations into two classes: 1. Boulder-clay; 2. Drift-sand and gravel; and he seems to have regarded the Boulder-clay as all of the same age. This I believe to be a fundamental error, which throws into confusion the whole account of the order of these deposits.

It is hardly necessary to remind readers of the GEOLOGICAL MAGAZINE of the three or four great periods in the hypothetical history of the last geological age of the British Isles, and of the whole of Northern Europe and America, as it is summed up by Sir C. Lyell in the last editions of his 'Principles' and 'Elements,' and in the 'Antiquity of Man,' *viz.*:—

1st. A continental period, when the land was much higher than at present, and all, except perhaps the summits of the highest mountains, was covered with a thick sheet of ice.

2ndly. A period of gradual submergence, in the later part of which icefloes and icebergs drifted to and among these islands, and their highest portions formed an archipelago in the North Sea.

3rdly. A period of emergence ending in a second continental condition, when, however, the land was probably not so high as in the first period, though glaciers occupied the higher valleys.

8. "On the Geology of the Isle of Man." By the Rev. J. G. Cumming. Part I. Palæozoic Rocks. Part II. Tertiary Formations, with Plates xiv.–xvii. Quart. Journ. Geol. Soc. vol. ii. 1846.
9. "On the Geology of the Calf of Man," by the same. Quart. Journ. Geol. Soc. vol. iii. 1847.
10. "The Isle of Man: its History," etc., by the same. London, Van Voorst, 1848.
11. "On the Superior Limits of the Glacial Deposits in the Isle of Man," by the same. Quart. Journ. Geol. Soc. vol. x. 1854.
12. "A Guide to the Isle of Man," by the same. London, Stanford, 1861.
13. "On certain Tracks in the Manx Slates." By Thos. Grindley, Esq. GEOL. MAG. Vol. II. p. 542. 1865.
14. "On the Geology of the Lake District and the Lower Silurian Rocks of the Isle of Man." By Professors Harkness and Nicholson. Quart. Journ. Geol. Soc. vol. xxii. 1866.
15. "Practical Guide to the Isle of Man." By H. J. Jenkinson. London, E. Stanford, 1874. Contains Chapters on the Mineralogy and Geology of the Island.

4thly. A second submergence, attended probably with many oscillations, until St. George's and the English Channels were formed, and the British Isles at length assumed their present shape.

I am not aware whether this hypothetical history—which, until some more satisfactory theory is suggested, must be assumed as the basis of all reasoning upon the Post-pliocene Formations—originally led to their threefold division into an Upper Boulder-clay, a Middle Drift of sand and gravel, and a Lower Boulder-clay, corresponding to, and by some supposed to be the product of the first three periods; but it seems not improbable.

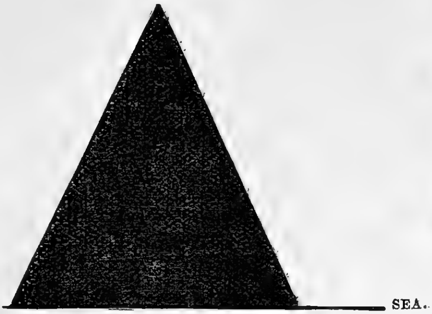
However this may be, the division now appears to be fully supported by facts, and it only requires some modification in the reference of the several members to their respective periods of formation to render it, apparently, satisfactory.

Thus, instead of assuming that the Lower Boulder-clay corresponds to and was entirely formed by land-ice during the first continental period, we believe that the materials of it were then ground up by land-ice and subsequently deposited in the sea, from the time when the land began to sink until perhaps the middle of the period of submergence.

Again, the Upper Boulder-clay was not formed altogether during the second continental period, but probably it was deposited during the middle or towards the latter end of the emergence, and continued to be deposited for some time during the second submergence; the interval between the middle of the first submergence and that of emergence being one in which a temperate climate prevailed and no glacial deposits were formed. The simple diagrams given on page 83 will illustrate my meaning at a glance.

Now to apply the above explanation to the glacial deposits of the Isle of Man. The whole northern portion, about a third of the island, north of the road from Ramsey to Kirk-Michael, is occupied by the Lower Boulder-clay and Middle Drift sands and gravel. It is best seen in the cliffs from Sea-view to Port Cranstal, at the eastern end of the Bride Hills, and again at the western end of the little chain at Blue Point. The sections are very similar, and consist of stratified yellow sand and gravel at the top, averaging 10 to 15 feet, succeeded by a great depth of brown clay, interspersed with patches of sand, and here and there a bed of gravel, and the whole attaining a maximum thickness, at Point Cranstal, of from 100 to 150 feet. The clay contains but few stones. The gravel-beds consist chiefly of local schist and quartz, with a very large admixture of stones foreign to the island—Permian rocks, chalk flints, granites, syenites, traps, porphyries, etc. The largest accumulation of pebbles from these beds is round the Point of Ayre, where the beach at low water, for a distance of nearly two miles, is composed of several terraces of shingle, apparently of considerable depth, and having a total width of 80 to 100 feet. Searching along this shore I found, besides the flints above mentioned, which must have come from the north-east of Ireland, a very great variety of granites, syenites, etc., probably part from Ireland, and part from the south of Scotland,

FIRST CONTINENTAL PERIOD.

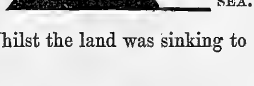


Maximum Height of Land.

FIRST SUBMERGENCE.

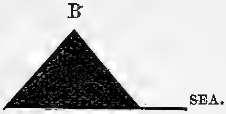
The Lower Boulder-clay would be forming, at first beyond the 100 fathoms line (see Map in "Account of the Isle of Man," p. 279), and afterwards among the British Isles till the land sank down to about the same elevation as at present, represented by—

A



Whilst the land was sinking to

B



Middle Drift Sand and Gravel would be formed chiefly by icefloes and icebergs drifted from foreign coasts.

C

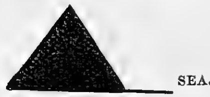
A temperate climate and no glacial formation.

EMERGENCE.

C

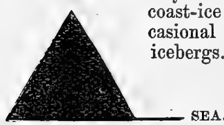
The same.

B

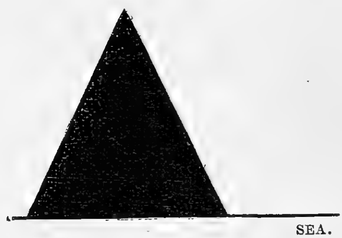


Upper Boulder-clay formed by coast-ice and occasional foreign icebergs.

A

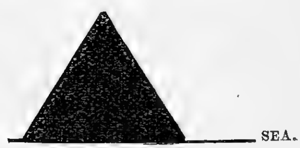


SECOND CONTINENTAL PERIOD.



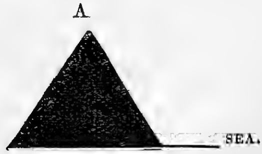
Maximum Height of Land.

SECOND SUBMERGENCE.



Upper Boulder-clay, continuing to be formed by coast-ice and occasional icebergs.

A



Present Elevation.

together with a profusion of traps and porphyries, some I believe from the Cheviots, and several specimens of *Prehnite* (or one of the same family of minerals) which (according to Hall's Mineralogist's Directory) is not to be found *in sitû* nearer than Beith in Ayrshire, or, in abundance, than Renfrewshire, or the Kilpatrick Hills in the neighbourhood of Glasgow.

The whole northern plain of the island—as may be seen by sections at Riversdale, on the banks of the Sulby river near Ramsey, on the roads to Kirk-Andreas and Kirk-Bride, and between the latter village and Blue Point, in the neighbourhood of Ballaugh, at Turby, and thence south to Kirk-Michael—is composed of similar deposits, all belonging, I believe, to the Lower Boulder-clay and Middle Drift. The same formations, or at least the sands and gravel, are to be seen at Peel in the west, and may be traced for some miles up the central valley of the island. They may be seen again along the railway from Ballasalla to Port St. Mary. A considerable thickness of the sands appears in a cutting of the same railway near Port Soderick, and they must be or have been present in considerable strength at Douglas, as the sandy shore and beach of the bay has no doubt been formed from their remains; though it is difficult, now that the land has been built over, to find any good sections.

If now we quit the shores, and ascend towards the higher ground and the mountains, we come to a totally different kind of deposit. It consists generally of a yellowish-brown, though occasionally bluish, or reddish, loam, containing angular fragments of almost exclusively local rocks, viz. Silurian schist with 'green-ash,' greenstone, and quartz, together with a few fragments of Old Red Sandstone, and a very few, if any not-derived, foreign rocks. This I believe to be the true Upper Boulder-clay. It may be traced from the southern extremity of the island, near Craigneesh (probably it is a patch of the same which is marked by Mr. Cumming on the Calf Islet), to the northern corner of Port Erin Bay, and thence along the southern base of the hills by Colby and Arbory, to Ballasalla. It is well seen in the cuttings of the railway thence to Douglas, and at the station there. It covers the cliffs at Douglas Head; it may be seen at several points along the road from Quarter Bridge to Onchan, and capping the cliffs on the northern side of Douglas Bay; it is traceable along the road above the valley of the Glass river from Douglas to Abbey Lands; it crowns the quarry at the side of the road from the Lunatic Asylum to Union Mills, is present in strong force there, and may be seen in every cutting of the railway thence almost to St. John's. In the north of the Island, too, one comes upon it directly on leaving the plain, as at the mouth of the Ballure Glen, at Ramsey, and on the left or mountain side of the road thence to Kirk-Michael. It is present also in the banks of the Foxdale river.

From the fact that this clay is found almost always at a higher level than the Middle Drift sands, and from its containing scarcely any but local rocks, and those always angular or in a very slightly rolled condition, I conclude that it is the wash of the mountains towards the later part of their rise and in the beginning of their second submergence in the sea, and due, partly to the action of the sea itself by tides and waves, partly to rainfall and an accumulation of snow and ice upon the land, combined with the most effective cause of all, the grinding of coast-ice swept along by violent currents.

If, referring to the diagrams at p. 83, it be asked why the same kind of deposit was not formed in the later periods, when the land was at the same height, as in the first submergence,—that is, why the Upper Boulder-clay is not precisely like the Lower Boulder-clay,—I can only suppose that there were other conditions besides the degree of elevation above the sea which would account for the difference, and, among these, perhaps the chief would be the enormous extent and mass of ice in the first period, forming a thick continental sheet, like that of Greenland now; while in the second period the ice was much more partial, and subject to disturbance which broke it up, and gave rise to "packing" and drifting. We must also remember that a portion of the sands and gravel of the previous deposits would be mixed with the later Boulder-clay—whence came its loamy character, and a proportion of, or perhaps all, the foreign rocks now found in it.

At the end of his "History of the Isle of Man," Mr. Cumming has given several sections, showing the Boulder-clay and Drift-gravel, in all of which he represents the former as extending underneath the latter.[1] My belief is that in this representation the Upper Boulder-clay, near the base of the mountains, has been confounded with the Lower Boulder-clay exposed in the coast cliffs, as at Point Cranstal, Blue Point, Turby Head, and Kirk-Michael in the north of the island, and perhaps also at Hango Hill in the south. Instead, therefore, of Mr. Cumming's division into a Boulder-clay and Drift-gravel, I would propose another into—

A. *Newer Glacial Formations.*

Upper Boulder-clay, containing almost exclusively local rocks, angular, or very slightly rolled, with occasional beds of sand and gravel.

B. *Older Glacial Formations.*

1. *Stratified sands and gravel,* containing an abundance of foreign (English, Scotch, and Irish) rocks well rolled.

2. *Lower Boulder-clay,* with patches of sand and gravel, containing a small proportion of foreign rocks.

In a word, I believe, from my own observation, that the conclusions as to the order of the glacial deposits adopted by the Geological Survey for the north-west of England and for Scotland, and announced by Prof. Hull[2] as holding good for the east of Ireland, are true also for the Isle of Man.

[1] See "History of the Isle of Man," by Rev. J. G. Cumming, plate viii.

[2] See an article "On the General Relations of the Drift Deposits of Ireland to those of Great Britain," by Edward Hull, F.R.S., etc., Director of the Geological Survey of Ireland, Geol. Mag. 1871, Vol. VIII. p. 294.

V.—Åsar, Esker, or Kaims.

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

As I have paid some attention to the Eskers of Ireland, perhaps I may be allowed to make a few notes on the papers of Mr. F. J. Jamieson recently read before the Geological Society of London, and the letter of M. Jespersen that appeared in the Geol. Mag. for December, 1874. These observers put forward the theory (if I understand them rightly) that these peculiar ridges of shingle, gravel, and sand may be in part glacial, they having been accumulated as marginal fringes to the different stages of the ice-cap that at one time covered the northern portion of the Continent of Europe, as it intermittingly retreated. This suggestion seems worthy of consideration, as possibly, if the ice-cap had an intermittent retrogression, there would be fringes or ridges of shingle, gravel, and sand marking each rest, formed of the detritus from each successive portion of the ice that disappeared; but such accumulations should be at different altitudes, and being carried by water off the ice, and deposited successively at its edge, should be stratified outwards,—or if the margin was retreating, they would be jumbled together.

Gravel ridges answering these requirements may occur in places; but if we examine into the facts connected with the great systems of eskers in Ireland, such a theory will not answer the requirements. The data connected with this phenomenon I have explained on former occasions,[1] and from those notes the following generalizations may be extracted.

First. The Esker ridges are usually stratified more or less in conformity with the slopes of both their sides; the stratification evidently being due to currents coming in different directions. *Second.* The well-marked eskers usually occur on ground between the 100 and 350 contour-lines. *Third.* When the eskers run on to ground above the 350 contour-line, they break into shoals or irregular mounds or accumulations, while the shingle, gravel, and sand graduates into the drift of the country; let the underlying drift be normal Boulder-clay-drift, Moraine drift, or the Glacialoid stratified drift. *Fourth.* The eskers or ridges occur in such places as it might be expected that tidal or other currents met; either in open seas, in straits, in bays, or estuaries. *Fifth.* The eskers or ridges may be divided into three kinds, namely: Fringe-eskers, margining high ground; Bar-eskers, stretching from one high ground to another; and Shoal-eskers, composed of short ridges and hillocks mixed irregularly together. While *Sixth.* From the charts we learn that nearly similar fringes, bars, and shoals are now being formed in the shallow seas, the straits, bays, and estuaries, by tidal and other currents.

If the great system of eskers in Ireland was due to detritus

[1] On the Eskers of the Central Plain of Ireland, *Dublin Quart. Journ. Science*, vol. iv. p. 109, and *Dublin Geol. Soc. Journ.*, vol. x. Notes on some of the Drift in Ireland, *Dublin Quart. Journ. Science*, vol. vi. p. 249, and *Journ. Royal Geol. Soc. Ireland*, vol. i. pt. iii.

margining the ice-sheet at its different periods of retreat, they scarcely could be so regular in character or on such similar levels over the whole island; besides, the stratification of the materials composing them ought always to dip in one direction, or be irregularly jumbled together. In some fringe-eskers, as pointed out in one of the papers previously referred to, the dip may in places be only to one side, but the reasons for this peculiarity are explained. If the sea, however, on account of the advance of the ice-sheet, had risen, all bars, fringes, and shoals due to it would be formed on the same or nearly similar levels, which, during the great "Esker-sea period," would be at heights lower than 350 feet; while to a sea of a lesser area and at a relative lower level would be due the esker ridges in the low level valleys, such as the esker across the valley of Lough Corrib, Co. Galway.

Although it seems to me that the great systems of eskers in Ireland are due to the meeting of currents in a tidal sea, [such a theory having been promulgated about ten years ago, and since confirmed by the observations of myself and colleagues], yet I am far from imagining that all eskers are due to marine currents, as some eskers are æolian, that is, principally formed by the wind; eskers of this class from half a mile to seven or eight miles in length being not uncommon in places on the east and south-east coast of Ireland, while inland in a few places are ridges of fine sand that probably had a similar origin. Furthermore, there are eskers evidently formed by the combined action of the waters of rivers and lakes assisted by wind, while in some of the Irish hills, and even on ridges, are eskers far higher than the limits of the "Esker sea," evidently due to some kind of waterwork, and not to wind action. Such eskers, indeed, might possibly be the remains of the sea work when its level was much higher than at present; this, however, appears very questionable, as the traces of such a sea-level ought to be more prevalent than they are, while as a rule in Ireland above the 350 feet contour-line the prevailing drifts are glacial or glacialoid. It seems, therefore, more natural to suppose, that while the great system of the Irish eskers was formed by marine action, small local systems or single eskers may be due to glaciers or some other cause. But I should not be surprised, if hereafter, when the Kaims of Scotland and the Åsar of Scandinavia are worked out in their entirety, that the main systems are found to be of marine origin. Before concluding I should mention that from the true Eskers or Åsar drift should be excluded the esker-like mounds or drumlins of Boulder-clay and Moraine drifts, that have by many eminent writers been confounded with the true Esker-drift, as has been pointed out by the Rev. M. H. Close in his paper on the General Glaciation of Ireland.

[1] General Glaciation of Ireland, Journ. Roy. Geol. Soc. Ireland, vol. i. part iii.

NOTICES OF MEMOIRS.

On the Conditions which Determine the Presence or Absence of Animal Life on the Deep-Sea Bottom. By Dr. W. B. Carpenter, F.R.S.[1]

THE foundation of Geological Science must be based upon a study of the changes at present going on upon the surface of the earth, including the depths of the sea. This is the distinctive feature of modern Geology. Until recently nothing was really known of the depths of the ocean; but, owing to improved methods of sounding, the bottom of the sea has been reached in so many places, that we may feel tolerably sure that its depth seldom exceeds four miles. Recent statements regarding an extraordinary depth off the coast of Japan are, most probably, due to an error similar to that which formerly represented the Straits of Gibraltar as unfathomable—an error caused by the carrying-out of the sounding-line in a strong surface-current. The general depth of the Atlantic does not exceed three miles, though, as an exception, the "Challenger" has recently attained 3800 fathoms in a hole 100 miles north of St. Thomas. As an additional proof that this was a true sounding, both the protected thermometers came up crushed.

The temperature of deep water has only lately been ascertained with accuracy, the earlier attempts having been vitiated by the error arising from pressure. Of the older attempts to ascertain the temperature of the deep strata, that devised by Lenz in the second voyage of Kotzebue, though fearfully laborious, gave results that correspond most closely with the "Challenger's"; a fact in scientific annals which has been lately dug out by Prof. Prestwich, and by him brought to the notice of the lecturer, who found his own conclusions —made in entire ignorance of those of Lenz—thus singularly confirmed. The conclusions to be drawn from a study of these temperatures point towards a deep flow of polar water towards the Equator, unrestricted, as regards the Atlantic, towards the south, but limited in the direction of the North Polar area, where there are two principal channels: the one between Greenland and Iceland, the other between the Faroe Islands and the 100-fathom line of North-west Europe, on which platform the British Islands repose. This latter is the "Lightning" channel, the scene of the lecturer's first explorations, the study of which led to his view of the existence of two opposite flows in the great oceanic area, quite irrespective of any one current. In this channel it was found that there was a superficial warm stream and a deep cold stream; and that within a vertical space of 50 fathoms a most marked difference of temperature is suddenly encountered; whilst, as regards horizontal distance, temperatures of 29½° F. and 43° F. have been obtained at the same depth in places not 20 miles apart. These facts mean that there are two distinct movements of water, just as a striking difference in the temperature of the atmosphere indicates a change of wind. Hence, speaking with reference to the "Lightning" channel, it is clear that

[1] Being the substance of a Lecture delivered before the Geologists' Association, on December 4th, 1874. Henry Woodward, Esq., F.R.S., President, in the Chair.

water much colder than the mean winter temperature of the latitude must have a northerly, whilst water that is warmer must have a southerly, source. In accordance with this we find that most of the animals of the cold area, such as the beautiful *Comatula Eschrichtii*, belong to the boreal fauna; whilst British species, such as the common *Solaster papposa*, which is dwarfed from the size of a plate to that of a crown-piece, are much stunted. Yet the fauna is abundant, as no temperature seems to prevent life, so long as sea-water is liquid. Pressure, though enormous, will not affect vital functions; since an animal, whose cavities contain air in aqueous solution only, can contract and expand just as well with a pressure of three tons to the square inch as it can on the surface. Not but what change of pressure, brought on by sudden removal, might produce some derangement. Neither temperature nor pressure, then, being directly of supreme importance, it is the supply of oxygen which has most influence on Animal Life in the deep seas. This is regulated by the general flow of water near the sea-bottom,—a flow not confined to any particular passage or area, but maintained by difference of specific gravity, produced by difference of temperature. As sea-water, in this respect differing from fresh-water, continues to increase in density down to its freezing-point, which is 27° F. if agitated, and 25° F. if still, the Polar column will outweigh the Equatorial column, and there will be a lateral outflow at the bottom towards the equatorial area. This will cause a lowering of water in the polar area, and produce a surface-flow of water from the Equator towards the Poles. The two bottom-flows from either pole will thus meet near the Equator, and rising, will bring cold water nearer to the surface there than anywhere else, except where the surface itself is subjected to cold. In this way the bottom-temperature of the South Atlantic would be lower than that of the North Atlantic, by reason of the less restricted body of the polar flow in the former. The tables given in the "Challenger's" report confirm the conclusions thus arrived at. From these we find that the general temperature of the North Atlantic bottom is about 35½° or 36° F., decreasing to 34° F. near St. Thomas, and under the Equator itself to 32·4° F., the lowest temperature of all. This section proves that the South Atlantic under-flow extends north of the Equator, as had been previously surmised by the lecturer. Only one section was made in the South Atlantic, and no temperatures lower than 33½° F. were there obtained, the expedition not happening to hit upon the channel which brought in the water at 32·4° F. found under the Equator. Most remarkable of all is the line of 35° F. which can be traced across the South Atlantic and then gradually slopes down in the North Atlantic till it is lost. The temperature of the North Atlantic depths is probably about 3° F. higher than in the South Atlantic. Off the coast of Lisbon, in lat. 38° N., the line of 40° F. is found at 700 to 800 fathoms; in lat. 22° N. at 700 fathoms; and on the Equator at 300 fathoms only, descending from a surface temperature of 75° F. The reason for this has been already shown to be the continual rise of the Polar under-flow towards the surface in the Equatorial belt.

A further confirmation of these views is obtained from a comparison of specific gravities. The density (due to salinity) of surface-water increases from the poles to the tropics, while that of bottom-water in the tropics is nearly the same as in the polar area. Why then does the bottom-water of the tropics, being of lower salinity, underlie the more saline strata? Because the density it lacks from its lower salinity is more than compensated by the lowness of its temperature. Passing, however, from either tropic towards the Equator, the salinity of surface-water is found to diminish, until its specific gravity is reduced from 1027·3 to 1026·4 or 1026·3, which is that of the polar under-flow. Lenz adduced the low salinity of the surface-water under the Equator as evidence of the rise of polar water from the bottom, and showed that there is a band of water at the Equator colder than any to the north or south of it.

The Oceanic Circulation thus produced brings every drop of water in turn to the surface, enabling it to part with carbonic acid and to absorb oxygen; this, then, is its importance to Animal Life. From the analysis of gases dissolved in the water of the oceanic area, it was found that, for 45 per cent. of carbonic acid, there was usually from 16 to 20 per cent. of oxygen—this being the result of a series of observations taken off Ireland and Scotland at various depths down to 2000 fathoms. This amount of oxygen is sufficient to support a large quantity of Animal Life, in spite of the, to air-breathers, fatal proportion of carbonic acid—if indeed the carbonic acid be not in a liquefied, and thus perhaps more innocuous form.

In the Mediterranean totally different conditions prevail. It was expected that a Tertiary fauna would be found at great depths, analogous to the Cretaceous-like fauna of the ocean outside. Instead of that, only a viscid mud, almost devoid of life, was brought up. The western basin has a depth of 1600 fathoms, the eastern basin one of 2000 fathoms; the bottom temperature is nearly uniform at about 55° F., a great difference in thermal condition from the Atlantic. The reason is that the Mediterranean is cut off entirely from the polar under-flow, which, off Lisbon, produces a temperature of 40° F. at a depth of 700 fathoms, and 36½° at 1500 fathoms. In the Mediterranean, on the other hand, we have a surface temperature from 60° to 70° F., which, in the first 100 fathoms, falls to 54° or 55° F., below which to the bottom, no matter at what depth, there is no change at all, but a slight variation according to latitude, due in part to the mean winter temperature of the locality. The whole of the lower portion, therefore, below the influence of the Gibraltar current, is a mere stagnant pool; and this is the explanation of the absence of Animal Life except in the shallows. The impalpable mud, which is slowly settling to the bottom, may also not be without its effect. This is the result of the attrition of soft Tertiary shores, and of the clay brought down by the Rhone into the western basin, and by the Nile into the eastern, the finer particles pervading the entire sea. Corals and Bivalves suffer from it especially, The per-centage of carbonic acid was found to be as high as 60, whilst that of oxygen was only 5; this is believed to be due to the organic matter, brought down by the rivers, using up the oxygen. These unfavourable conditions are primarily due to deprivation of the general oceanic circulation, which maintains life at such great depths.

There seems, however, to be a limit, in respect of depth, to the preservation of animal remains; due possibly, as conjectured by Prof. Thomson, to the solvent power of sea-water at pressures below 2200 fathoms. This may serve to explain the passage of true *Globigerina* ooze, first into grey ooze, poorer in calcareous matter, and finally at great depths into red ooze devoid of lime. Moreover, this dissolving of calcareous skeletons at great depths may serve to explain the production of Greensands, such as is now going on along the line of the Agulhas current. These consist largely of the internal casts of foraminifera, the sarcode of which has been replaced by glauconite). The importance of such facts to geologists is immense. It was the examination of a series of casts of similar bodies in a green silicate, that, years ago, formed the foundation for the lecturer's interpretation of the structure of Eozoön, where there is a replacement of its sarcodic body by a green silicate, viz. serpentine. If the sea-water, under this tremendous pressure, has dissolved away the shells of Foraminifera, after their sarcode has undergone the substitution alluded to, a beautiful application of this kind of research to geological phenomena has been brought forward.

Referring to Ed. Forbes's limitation of marine life to 300 fathoms, the lecturer observed that the statement was true of the Ægean, as of the whole of the Mediterranean, where there is abundant life in the littoral zone, diminishing rapidly towards 250 fathoms, below which Animal Life is almost at zero. Finally it is not a limit of pressure, of heat, or even of food, but the limit of oxygenation, as determined by the presence or absence of a thermal circulation, which affects the life of animals. So that deposits forming in inland seas, excepting in the shallower portions, we must expect to be destitute of fossils. This is well illustrated by the Miocene strata of Malta, where certain coarsish beds, representing shallow water conditions, are full of fossils in a fine state of preservation; whilst the very fine building stone, corresponding closely with the finest calcareous deposit of the Mediterranean, contains hardly any remains but such as would fall in from above, *e.g.* the teeth of sharks. This may explain the paucity of fossils in many strata, especially in the Red Sandstones of inland seas. Much depends upon the depth of the communication, supposing there to be one, with the oceanic circulation; and the level of this may be often inferred from a knowledge of the line of permanent temperature of such inland sea. To the general paucity of animal life under such conditions the Red Sea appears to be an exception, notwithstanding the shallowness of the Straits of Babelmandel. This is probably due to the absence of the sediment and oxidating matter of large rivers, and to the rocky nature of its shores, conditions which insure a clear water; whilst a certain circulation, producing oxygenation, is kept up to supply the enormous evaporation, which, if the Straits were closed, would desiccate the basin in three or four hundred years.

REVIEWS.

Leonhard und Geinitz's "Neues Jahrbuch für Mineralogie, Geologie und Paläontologie." Jahrgang 1873. Hefte 1–9.

THE many memoirs, and the numerous letters to the editors from active and well-known geologists and mineralogists, make this as rich as any former volume in original matter; whilst the bibliographical register of published memoirs, and the multitudinous abstracts of books and papers, treating of mineralogy, crystallography, mineral-chemistry, geology, and palæontology, render the *Neues Jahrbuch* indispensable to working geologists of every turn of mind, who wish to keep up with the current literature of their science. As original memoirs they will find, in Palæontology:—E. von Eichwald on the limbs of the Trilobite (with plate i.); H. B. Geinitz on the Cretaceous *Inocerami;* Zelger, *Terebratula vulgaris* in the Gypsiferous Keuper of France; E. Geinitz, Fossils (Insects and Plants) of the Bituminous Shale of the Lower Dyas (Permian) of Saxony (plate iii.); C. W. Gümbel on Coccoliths, Limestone, and Oolite; Fr. Schmidt on *Pteraspis Kneri*; etc.

In Geology:—Ferd. Römer's tour in the Sierra Morena; H. Loretz on the Alpine Trias, etc., in South-Tyrol; F. Sandberger on the Miocene formations in the Swiss and Swabian Jura; C. Naumann on the younger Gneiss near Frankenberg in Saxony (woodcuts); H. Laspeyres on the marine origin of the Rothliegende of Saxony; E. Cohen, Geological Notes on Griqualand, Transvaal, and the Diamond Diggings and Gold-fields of South Africa; R. Drasche, Geological Notes on Christiania and Spitzbergen; A. Jentzsch on the causes of the Glacial Period; H. Hofer, the Ice-age in Mid-Carinthia; A. Streng, the Circulation of Matter in Nature; G. vom Rath, the Belluno Earthquake; Al. Stelzner's tour in the Argentine Provinces San Juan and Mendoza; etc.

In Petrology and Mineralogy:—G. vom Rath on the crystallographic system of Leucite (plate ii.), and on the Sulphur-mines of Girgenti; A. von Lasaulx on Ardennite; A. Streng on some Porphyrites; Th. Petersen, the Basalt and Hydrotachylyte near Darmstadt; Burkart, some Tellurium Minerals from North America; C. Dölten, the Tuff-rocks of South-Tyrol; Th. Scheerer, the Genesis of Granulite; H. Möhl's microscopic examination of some basalts of Baden (plate iv.); H. Bahren's Spectrum of Opal (plate v.); A. Knop, Petroleum in the Odenwald; and mineralogical papers by A. Frenzel, F. Wibel, H. Schröder, Kenngott, Ad. Pichler, Laspeyres, A. Knop, and others.

T. R. J.

REPORTS AND PROCEEDINGS.

Geological Society of London.—December 2, 1874.—John Evans, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "On the Femur of *Cryptosaurus humerus* (Seeley), a Dinosaur from the Oxford Clay of Great Gransden." By Harry Govier

Seeley, Esq., F.L.S., F.G.S., Professor of Physical Geography in the Bedford College, London.

The author described this femur as showing a slight forward bend in the lower third of the shaft, and as having the terminal portions wider in proportion to the length of the bone than in any described Dinosaurian genus. He pointed out its differences from the corresponding bone in *Megalosaurus*, *Iguanodon*, and other genera. The length of the femur was stated to be about one foot.

2. "On the Succession of the Ancient Rocks in the vicinity of St. David's, Pembrokeshire, with special reference to those of the Arenig and Llandeilo groups and their fossil contents." By Henry Hicks, F.G.S.

In the first part of this paper the author described the general succession in the rocks in the neighbourhood of St. David's from the base of the Cambrian to the top of the Tremadoc group, and showed that they there form an unbroken series. The only break or unconformity recognized is at the base of the Cambrian series, where rocks of that age rest on the edges of beds belonging to a pre-Cambrian ridge.

In the second part the author gave a minute description of the rocks, comparing the Arenig and Llandeilo groups, as seen in Pembrokeshire, with each other, and also with those known in other Welsh areas.

Each group he divided into three subgroups, chiefly by the fossil zones found in them.

1. The *Lower Arenig* was stated to consist of a series of black slates about 1000 feet thick, and to be characterized chiefly by a great abundance of dendroid graptolites.
2. *Middle Arenig.* A series of flags and slates, about 1500 feet thick, and with the following fossils:—*Ogygia scutatrix*, *O. peltata*, *Ampyx Salteri*, etc.
3. *Upper Arenig.* A series of slates, about 1500 feet in thickness, only recently worked out, and found to contain a large number of new and very interesting fossils belonging to the following genera: viz. *Illænus*, *Illænopsis*, *Placoparia*, *Barrandia*, etc.
4. *Lower Llandeilo.* A series of slates and interbedded ash, equivalent to the lowest beds in the Llandeilo and Builth districts, and containing species of *Æglina*, *Ogygia*, *Trinucleus*, and the well-known graptolites *Didymograptus Murchisoni* and *Diplograptus foliaceus*, etc.
5. *Middle Llandeilo.* Calcareous slates and flags, with the fossils *Asaphus tyrannus*, *Trinucleus Lloydii*, *Calymene cambrensis*, etc.
6. *Upper Llandeilo.* Black slates and flags, with the fossils *Ogygia Buchii*, *Trinucleus fimbriatus*, etc.

The Arenig series was first recognized in North Wales by Prof. Sedgwick about the year 1843, and was then discussed by him in papers presented to the Society. The Llandeilo series was discovered by Sir R. Murchison previously in the Llandeilo district, but its position in the succession was not made out until about 1844. The Geological Survey have invariably included the Arenig in the Llandeilo group; but it was now shown that this occurred entirely from a mistaken idea as to the relative position of the two series, which were now shown to be entirely distinct groups, the equivalents of both groups being present in Carnarvonshire, Shropshire, and Pembrokeshire, but the Llandeilo group only of the two being developed in Carmarthenshire.

The lines of division in the series were said to be strongest at the top of the Menevian group and at the top of the Tremadoc group, these lines being palæontological breaks only, and not the result of unconformities in the strata.

Discussion.—Professor Ramsay complimented the author on having brought forward a paper so well worked out. He gave an account of his own early geological work in Wales, and stated that he had mapped the rocks referred to by Mr. Hicks in 1841. He differed from the author in believing his supposed Laurentian rocks to be igneous. They were metamorphosed Cambrian deposits, which had lost all traces of their aqueous origin. In 1841, no fossils had been found below the Llandeilo Flags in any part of the series described by Mr. Hicks, and thus there was no ground for establishing those palæontological divisions in the series which were indicated in the present paper. He stated that he traced the line between the blue flags and the Cambrian slates, and believed that it would show an unconformity between the Tremadoc slates and the Lower Llandeilo.

Prof. Hughes observed that the fossils by which the rocks under discussion were subdivided did not occur all through the several groups, but only in widely separated zones; and that between those zones sometimes one line and sometimes another had been taken as the arbitrary boundary, often to be shifted in consequence of the discovery of other fossiliferous bands. The line referred to by Prof. Ramsay, as that which he was tracing in North Wales for the base of his Llandeilo, was a most useful line to draw, as helping to trace horizons, but was not shown to be coincident with any great break in succession. The Silurian system had not and, after several changes, has not for its upper boundary a line representing any break in the continuity of deposition. Nor had it at first nor has it now, after much modification, any well-defined natural boundary for its base-line. The only break in it is that which occurs at the base of the May Hill Sandstone, and that was unrecognized till pointed out by Prof. Sedgwick, many years after the publication of the "Silurian System," the author of which, seeing that his system had no base on which to rest, took in group after group of the underlying series, and to justify himself had to prove at each step that, as yet, no break had been found in the series; till at length he got down to the lowest Cambrian, part of which he included in his Primordial Silurian. It was now well known, and that chiefly through the labours of Mr. Hicks, that no strong line could be drawn there, and we must therefore take it down to the bottom of the Cambrian conglomerate, or up to the base of the May Hill Sandstone. Between these horizons lie the Cambrian rocks of Prof. Sedgwick, a well-defined natural group and an ancient name, which, following the true principles of classification and justice in our nomenclature, we must adopt.

Mr. Etheridge remarked that several species pass up from the Tremadoc into the Llandeilo, and that the line between the Tremadoc and the Llandeilo of Sedgwick was not settled. In all cases of this kind stratigraphical or palæontological evidence alone was not sufficient, the two required to be concordant. He entered at some length into the palæontological statistics of the deposits under discussion, and dwelt especially on the fact that of 70 species of fossils found in the Tremadoc, only four pass up into the Arenig. The break at the top of the Tremadoc was thus palæontologically of great importance, although not apparent stratigraphically. Hardly any of the Lower Llandeilo (or Arenig) species agree with those of the Llandeilo Flags. The species at the top of the Stiper have a peculiar facies of their own, and would not be recognized as Arenig.

Prof. Seeley said that the subdivisions of the Cambrian series of Sedgwick were based solely on palæontological evidence, and that to the physical geologist the deposits formed a single series, which could be subdivided upon stratigraphical grounds. But although there was no evidence of unconformity between the strata, he thought that the fact of different groups of fossils succeeding each other in the same area showed that those groups existed in neighbouring seas, and had been driven by upheaval of the sea-bottom on which they lived, into the region in which they are found. Hence he maintained that a change in the forms of life is evidence of unconformity in an adjoining area.

Mr. Maw remarked that under the Cambrian rocks at Llanberis there are unconformable beds, which may be the equivalents of the so-called Greenstones of St. David's.

Mr. Hicks admitted that the subdivisions at present in use may need to be modified. He thought that the greatest break is between the Menevian and the Lingula Flags, few species passing from one to the other. He regarded the upper and lower portions of the Tremadoc as really distinct.

CORRESPONDENCE.

VOLCANIC ROCKS OF THE LAKE-COUNTRY.

Sir,—As much interest attaches to the question of the relation of the volcanic rocks of the Lake-country (the Green Slate and Porphyry series) to the older Skiddaw Slates, and as one of us formerly expressed an opinion on the subject contrary to what the subsequent researches of the Geological Survey have made out, it may interest some of your readers to learn that we have lately discovered in Swindale, near Shap, beds of volcanic ash of the Green Slate and Porphyry series clearly interbedded with the Skiddaw Slates, similar to the case discovered by Mr. Aveline near Black Comb.

J. R. Dakyns, Kendal,
J. Clifton Ward, Keswick.

DEEP BORING IN PRUSSIA.

Sir,—I send you some particulars, with which I have lately been favoured by Professor A. von Koenen, of Marburg, respecting the deep boring made by the Prussian Government Engineers at Sperenberg, about 25 miles south of Berlin, and noticed by your correspondent J. P. at page 48 of the Geological Magazine for January.

The boring for the first 956 feet (1297¼ English feet) was made by manual labour, at a cost of about £1600.

Several accidents having happened, the borehole was then lined for a depth of 85 feet (115¼ English feet) with tubes of 15 inches diameter; beyond that, to the depth of 100 feet (135 English feet), with 14-inch tubes; and then to 363½ feet (493¼ English feet) with tubes of 12½ inches diameter.

The length of time occupied in the above-mentioned work was fifteen months—comprised between May, 1867, and July, 1868.

From the depth of 956 feet (1297½ English feet), for the remaining distance, the boring was carried on by means of a steam-engine. The length of time consumed in sinking this additional 3095 feet (4255 feet English), comprised between January, 1869, and the 15th September, 1871, was about 31½ months, or 2 years and 7 months; during which interval several accidents occurred.

The total expenditure upon the whole boring, 4051 feet (5570 English feet), both by manual labour and by steam power, was about £8717 14*s.*—making the average cost for every Prussian foot in depth about 2 guineas, or £1 11*s.* 4*d.* per English foot.

The whole time spent on the work was 51½ months, or 4 years and 3½ months; but as there was an interval of 5 months, between July, 1868, and January 1871, during which period the boring operations were suspended, the actual number of working months becomes reduced to 46½.

The process of boring throughout was by percussion borers worked by rods; and the rocks bored through belonged to the Triassic series.

The progress of the work would have been much greater but for the accidents which took place, and for the delays which were caused by the observations that were made as to the increase of the temperature of the earth in depth, etc.

The measurements were taken in Prussian feet; these have been reduced to English feet—the Prussian foot being 12·357 English inches.

A memoir ("Die Tiefbohrung zu Sperenberg") on the subject of this interesting undertaking will be found in the "Zeitschrift für das Berg- Hütten- und Salinen-Wesen in dem Preussischen Staate," Band xx. 1872.

H. W. Bristow.

28, Jermyn Street,
January, 1875.

THE GREAT RHÆTIC BONE-BED NEAR FROME.

Sir,—To those of your readers who make a special study of the Rhætic beds, it may be of interest to know that the great Bone-bed, situate in the Black Shales of the above series, and replete with its usual remains, has been met with at the depth of 310 feet, in a pit, at present being sunk by James Oxley, Esq., of Frome, to the Lower Series of Coals of the Somersetshire basin, about two miles N.W. of Frome, and on the S.E. flank of the Mendip Hills.

Alfred C. Crutwell.

West Hill, Frome,
15 *Jan.* 1875.

MISCELLANEOUS.

Artesian Well at Torquay.—The Diamond Boring Company are sinking an artesian well on the premises of the Torquay Brewing Company, in Fleet-street, Torquay. About 90 feet of solid limestone (Devonian) has been penetrated. It is anticipated that an abundant supply of water will be reached at a depth of about 200 feet; but although this may be regarded as very problematical, there is no doubt that if the work proceeds a very interesting geological section will be obtained.

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

No. III.—MARCH, 1875.

ORIGINAL ARTICLES.

I.—"UNIFORMITY" AND "VULCANICITY."

By the REV. O. FISHER, M.A., F.G.S.

SOME geologists there are who are prevented from carrying out on an extended scale observations in the field. They may well envy those who have the strength, leisure, freedom from local duties, and means to travel. Such accurate descriptions as they receive from a pen like Mr. Judd's, enable them to see with other eyes, and to test the theories which they spin out of their brains by wider information. They must accept their position, and either speculate, or do nothing, in their favourite science. Happily Mr. Judd admits that speculation has its value, and Mr. Clifton Ward is of the same opinion.

But we are warned not to "abandon those safer methods of inquiry based on the doctrine of Uniformity," nor "to revert to the earlier methods—in effect, to substitute cosmogony for geology."[1]

What is meant by the doctrine of Uniformity? If it be simply that like forces have produced like results in all former times to what they produce at present,—in other words, that the laws of nature have never changed,—then no doctrine can be more certain. But if it teaches that "all things continue as they were from the beginning of the creation,"—in other words, that the forces of nature act upon matter which has always been in the same condition as at present,—then I submit that the doctrine of Uniformity itself ought to be "abandoned." To apply the principle to Vulcanology: "It would be very wonderful, but not an incredible result, that volcanic action has never been more violent on the whole than during the last two or three centuries; but it is as certain that there is now less volcanic energy in the whole earth, than there was a thousand years ago, as it is that there is less gunpowder in a "Monitor," after she has been seen to discharge shot and shell, whether at a nearly equable rate or not, for five hours without receiving fresh supplies, than there was at the beginning of the action."[2]

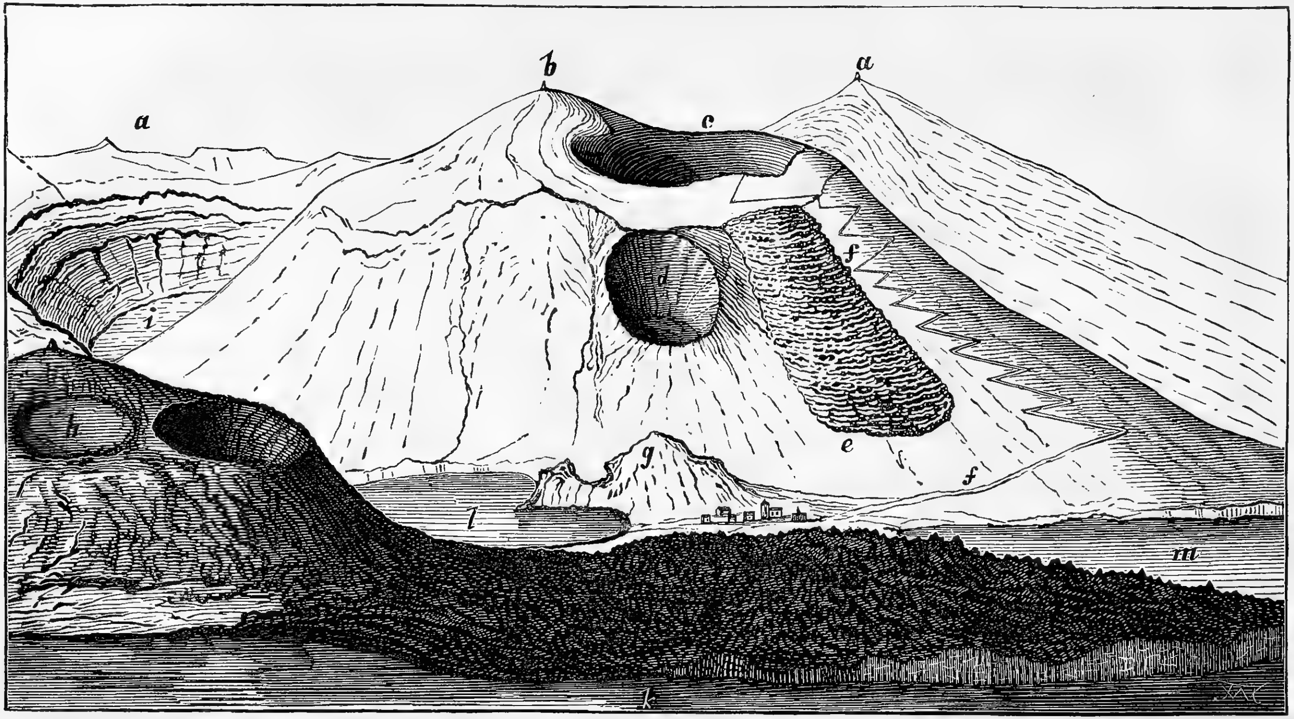
If the doctrine of Uniformity in this sense be untenable in its application to the condition of the earth in all past time, then we are necessarily led backwards to cosmogony; and I cannot see why our science should not be permitted to connect itself with cosmogony at the one extremity, as it has lately become firmly united to archæology at the other. "The earlier methods" led often to

[1] Mr. Judd, On Volcanos, GEOL. MAG. Dec. II. Vol. II. p. 3.
[2] Thomson, On the Secular Cooling of the Earth, Nat. Phil. p. 714.

fallacious results, because the facts of Geology were then little known. Speculation preceded observation. But we have now immense stores of observations, by which speculation may be guided; and if speculators are not so perfectly acquainted with these as observers are, the latter can check them, and they are, as Mr. Ward has proved himself, fully equal to the task.

To follow speculation to its legitimate conclusions, some knowledge of mathematics, physics, and chemistry are needed, as Mr. Mallet truly tells us. The philosophical method appears to be, in Geology as in other kindred sciences, to start with a probable hypothesis, and, following it to its necessary consequences, to inquire whether these harmonize with observed facts. It is here that mathematics finds its proper field. That science is a mode of reasoning, unerring in its methods, but wholly dependent for the truth of its results upon the premisses, assumptions, and limitations, according to which the inquiry is conducted. If the result turns out to be erroneous, it is not the method which ought to bear the blame, but the original hypotheses.

Mr. Mallet has lately cast down his gage with so loud a ring that he has arrested general attention, and his theory of Vulcanicity is so ingenious and so bold, that it appears to have thrown many minds into one of two states, which are, either of them, unfavourable to calm inquiry. Those whose views are called in question reply in a spirit as eager as that in which they have been challenged; while others, charmed with the novelty and seeming simplicity of the theory, embrace it as of course. For my own part I cannot say that my mind is at all made up upon the subject; and it needs more study than I have been able to give, before I can persuade myself that I even understand his argument. But I am free to allow that I consider Mr. Mallet's paper in the Philosophical Transactions an important work. The mere experiments upon the resistance which different rocks offer to crushing, the elaborate tables founded upon them, the investigations on the fusion of slags, and their contraction in cooling, with the tabulated results—all these, apart from any conclusions drawn from them, are of very great value. Whether the theory of Vulcanicity, which the author builds upon these experiments, is their legitimate outcome, is the point really in question. Yet as far as I have seen, it has been barely touched by his critics. The question when simply stated appears to be this. Is the superheated interior of the earth so deeply buried at the present time as to render it highly improbable that volcanos should be channels of communication between it and the surface? Mr. Mallet believes that it is too deeply buried, and suggests a secondary cause, due ultimately, nevertheless, to the presence of a heated interior, and so accounts for volcanic action. Mr. Scrope, on the other hand, inquires, why, admitting a heated interior, should it be sought to bring in a secondary cause in order to account for the superficial manifestations of its presence. This query is clearly pertinent. Yet, for all that, it may have to be answered that such a secondary cause is necessary. So the question might be asked and answered,



SKETCH OF THE GREAT CENTRAL CONE OF VULCANO, WITH VULCANELLO IN THE FOREGROUND, AND THE OLDER ENCIRCLING CRATER-RINGS IN THE DISTANCE, AS SEEN FROM ABOVE PUNTA DELLA CREPAZZA, IN LIPARI.

aa. Outer crater-rings culminating in Monte Saraceno. *b*. Highest point of the central cone. *c*. Great crater. *d*. Small crater, called the Fossa Anticcha. *e*. Obsidian lava-stream of 1775. *ff*. Road leading into the crater. *g*. The Faraglioni, with the "Fabbrica" near it. *h*. Vulcanello, with two of its craters seen. *i*. The Atrio between the outer crater-rings and the central cone. *k*. Lava-streams proceeding from Vulcanello. *l*. Porto di Levante. *m*. Porto di Ponente.

Why look to a secondary cause to account for the fire which flies from the wheel of a railway carriage, when the brake is applied, knowing that a hot furnace is burning in the engine. The two cases are more nearly parallel than they appear.

Before the matter in dispute can be settled, Mr. Mallet's theory needs to be criticized closely from his own point of view, to inquire whether he is justified in claiming for it a capability for producing the actual phenomena of vulcanicity, both present and past. And even if it should turn out to be capable of that, Mr. Scrope's view may still be concurrently true, unless it can be shown that no direct communication can exist between the surface of the globe and its heated interior. That part of Mr. Mallet's conclusions which Mr. Ward refutes does not appear to be of the essence of the question. Indeed a convert to his main theory might hold quite different opinions from his with respect to the sequence and formation of some of the great features of the globe.

II.—Contributions to the Study of Volcanos.

By J. W. Judd, F.G.S.

(*Continued from page* 70.)

The Lipari Islands.—Vulcano.

(PLATE VII.)

During the earliest periods concerning which we have historical records in Southern Europe, Vesuvius was certainly inactive, its true character, indeed, long remaining wholly unsuspected; nor do the eruptions of Etna at this epoch appear to have been of such a character as to have powerfully arrested the attention and excited the imaginations of the oldest inhabitants of the district. Far otherwise was it, however, with the volcanos of the Lipari Islands; in these the manifestations of igneous activity had been so constant and striking, that priests, poets, and philosophers had successively associated the locality with their most marvellous stories.

Identified in the older mythologies with the forge of Vulcan and the workshop of the Cyclops, it is not surprising to find the superstitious mariners applying to the southern and more violently active of the Lipari volcanos the name of Hiera—or the Sacred Isle. And its vast crater, presenting by day bellowing fumaroles, and by night glowing fires, is not inappropriately selected by Virgil as the scene of the forging of the armour of Æneas.

In later times, when fear and fancy had begun to give place to curiosity, the historians, geographers, and philosophers of Rome gave more sober and accurate accounts of the phenomena of this island; and its later name of "Vulcano" or "Volcano" has gradually come to be applied to all mountains where igneous forces are similarly displayed. Nor, as we shall attempt to show in this chapter, is this volcano unworthy of the distinction which it thus accidentally acquired—that of serving as the prototype of all the members of its class. Observations, carried on during longer periods, and over far larger portions of the earth's surface, have made us acquainted with many grander volcanic piles and with more striking manifestations of igneous action; yet it may, perhaps, be doubted whether in any of these the nature, products, and causes of the phenomena displayed can be so advantageously studied as in Vulcano.

In seeking to sketch the early history of this volcano it would be a hopeless task to attempt the separation of truth from its embellishments in the legendary stories of the oldest classical writers; yet we may at least accept the traditions associated with Vulcano as proving that, during the earliest periods of the occupation of the district, its outbursts had been both frequent in their occurrence and striking in their characters. As we come to later times, however, more trustworthy statements concerning its general condition and its paroxysmal displays of violence are found, in the writings both of geographers and historians.

Thucydides, in the fifth century before Christ, speaks of Vulcano as throwing out a considerable smoke by day and flame by night. The appearance of flames was doubtless due, as in all volcanic eruptions, to the reflexion of glowing surfaces of lava in the crater from the clouds of ejected matter rising above it, or to fragments of incandescent solid or liquid matter mingled with the latter.

In the next century, Aristotle records a grand eruption of Vulcano, during which a new hill was formed; the quantity of ashes thrown out being so great as to entirely cover the city of Lipari (six miles distant from the volcano), and to extend to several of the towns of Italy. This eruption had not entirely ceased at the time when Aristotle wrote.

Callias, writing in the third century before Christ, describes Vulcano as possessing two craters; one of which was nearly 2000 feet in circumference, and threw out burning stones of prodigious size, with a noise that could be heard at a distance of more than fifty miles.

In the next century a very remarkable and important eruption took place, during which a new island gradually rose above the sea-level, great numbers of fish being killed. This account is usually interpreted as applying to the formation of Vulcanello. Posidonius, Pliny, and other writers who record this interesting event, are not, however, agreed as to the exact year in which it took place. From an account of Vulcano, written in this same century by Polybius, and preserved by Strabo, the mountain appears to have had three craters, two tolerably well preserved, and one in part fallen in. The larger crater was round, and about 1000 yards in circuit; its interior was funnel-shaped, the bottom of it being only about 50 feet in diameter, and 600 feet above the sea-level. It is clear that these observations must have been made during a period of inactivity in the volcano.

Diodorus, who was a native of Sicily, speaks of Vulcano in his time, namely the century before the Christian era, as throwing out burning stones, like Stromboli and Etna. Strabo, who wrote just before the time of Christ, tells us that the three openings or craters of Vulcano ejected ignited matters, that filled up a part of the sea to a considerable extent. We may also infer from the account of Strabo that Vulcano ejected lava in his time.

Lucilius Junior, Pliny, and Mela Pomponius, all of them writing in the first century of the Christian era, speak of Vulcano as being in a state of activity.

As soon, however, as we lose the guidance of the classical authors, the history of Vulcano becomes involved in the greatest obscurity. The inhabitants of the Lipari Islands suffered greatly from the invasions of pirates and slave-hunters, a circumstance of which the name of "Monte della Guardia," applied to the highest summits in almost all of the islands, furnishes a melancholy testimony. It is not therefore surprising to find that the Liparotes gradually acquired a ferocity of disposition, which caused their inhospitable shores to be shunned by mariners during the lawless mediæval times. So late, indeed, as the last century, the evil reputation of the islanders was such as to prevent travellers from venturing among them; and it was not until the Mediterranean was cleared of the Barbary pirates, at the commencement of the present century, that these islands could be visited with perfect safety.

The long period of obscurity, to which we have alluded, is only broken by a brief reference of Eusebius, and another by Orosius, in the fifth century; and by the following, perhaps legendary, account:

In a biography of St. Willebald, who is said to have lived between the years 701 and 786, there occurs the following passage:—"From Reggio St. Willebald sailed to see Vulcano, one of the Lipari Islands, then in a state of eruption. The saint wished to obtain a view of the boiling crater, called the '*infernum of Theodoric*,' but they could not climb the mountain from the depth of the ashes and scoriæ. So they contented themselves with a view of the flames, as they rose with a roaring like thunder, and the vast column of smoke ascending from the pit."

It would seem from this passage that, if Vulcano had lost the reputation of being the forge of Vulcan, its state of activity and the terrors which it inspired during the Dark Ages were such as to cause it to be identified with a still more dreadful place. Brydone, visiting Etna in 1770, found the Sicilian peasants holding the belief that its crater was the place of confinement for poor Anne Boleyn, who had exercised so unfortunate an influence on the "Defender of the Faith." Vulcano appears, in still earlier times, to have been fixed upon as the place of torture for an Arian emperor.

The modern history of Vulcano commences with the accounts given by Fazello, who was a native of Sicily, and lived between the years 1490 and 1570. He states that on the 5th of February, 1444, a great eruption occurred, which shook all Sicily, and alarmed the coast of Italy as far as Naples; the sea is declared to have boiled all around the island, and rocks of vast size to have been discharged from the crater. A number of submarine eruptions are said to have taken place all round the island, fire and smoke rising above the waves; and as the result of these the navigation around the island was totally changed, rocks appearing where there was before deep water, and many of the straits and shallows being completely filled up. At a later period, Fazello appears to have himself visited the island, and relates that the mountain was in a state of continual conflagration. He states that from its gulf (crater), which lay in the middle of the island, a cloud of thick smoke continually issued, while through the fissures of the stones and narrow apertures a pale flame arose in the midst of a dark cloud. It would thus appear that, after the grand outburst in the fifteenth century, the volcano relapsed into a condition similar to that which it now presents. Another interesting fact recorded by Fazello is, that in his time Vulcanello was still a distinct island, separated from Vulcano by a narrow channel, in which ships could lie in safety; but that this channel was subsequently filled up by new eruptions.

Fresh outbursts of Vulcano appear to have occurred early in the seventeenth century, for Cluverius states that, standing on the opposite shores of Sicily, he could perceive fire and dark smoke arising from the mountain.

Father Bartoli, who visited the island in 1646, relates that "it contained a deep gulf, entirely in a state of conflagration within, and, in a small degree, to be compared to Etna; and from its mouth a copious smoke continually exhaled." This appears to have been a time of comparative rest in the volcano.

In 1727, however, when M. d'Orville visited the island, the volcano was certainly in a much more active state. It had then two distinct craters, each of which was situated at the summit of an eminence. From the most southern of these, which was about a mile and a half in circuit, there was ejected, besides "flame" and smoke, ignited stones; and its roaring was not less than the loudest thunder. From the bottom of the gulf rose a small hill about 200 feet lower than the top of the crater, and from this hill, which was entirely covered with "sulphur" and dirty corroded stones, fiery vapours exhaled in every part. M. d'Orville had, however, scarcely reached the edge of this "burning furnace," when he was obliged to retire precipitately.

The second crater lay towards the northward of the other. Its "conflagrations" were more frequent and ardent; and its ejections of stones, mixed with ashes and an extremely black smoke, almost continual. M. d'Orville further relates that the noise of this volcanic island was heard for many miles; and was so loud at Lipari (six miles away) that he could not sleep the whole night that he remained there.

This very clear and explicit account of the state of Vulcano is of great interest to us, exhibiting as it does a distinct image of the two cones and craters upon the great line of subterranean fissure and the rise of an internal cone from the bottom of one of them. More than sixty years after, Spallanzani found that some of the oldest of the inhabitants of Lipari still retained an imperfect recollection of the existence of the two craters.

At what period these were obliterated and the single cone formed, we have not the means of exactly determining. It is clear that between the years 1730 and 1740 the volcano was in a state of almost continual eruption; the Abbe Don Ignazio Rossi, a native of the island of Lipari, kept a diary of observations made during these years, which was published in 1761 by Signor Don Salvadore Papacuri of Messina. Rossi speaks of an almost continual discharge of ashes and smoke taking place, sometimes rising in clouds of great density, and at other times accompanied by explosions of great violence, earthquake shocks and loud roarings. He believed from his observations that the changes in the condition of the volcano were related, in some way or other, to the variations in the state of the atmosphere and the directions from which the wind blew. This question we shall have occasion to refer to more particularly hereafter. Deville speaks of violent eruptions having taken place in 1731 and 1739.

That a series of almost continual ejections during more than ten years should have greatly affected the form of the cone and crater of Vulcano is no more than might have been expected. Fortunately, we have in the "Travels" of M. W. de Luc an account of the state of the volcano in 1757. He appears to have been the first writer on the island who ventured to enter the crater. On the 30th of March, in the year mentioned, he managed to reach the bottom of the crater by a narrow passage (probably a great fissure rent in the side of the cone, like that produced in Vesuvius in 1872), which afforded him admission to the interior, but at great risk of being suffocated by the dense sulphurous fumes that enveloped him. His guide, a native of Lipari, refused to accompany him. He describes the bottom as being very rugged and uneven, with a number of apertures, from some of which issued a "strong wind," and from others sulphurous vapours, while an abyss, 60 paces in circuit, near one of the sides, gave off a column of smoke 15 or 18 feet in diameter, with a roaring sound "like that of the vapour of boiling water, when it escapes from a vessel not closely covered." The floor of the crater is described as oval in form, with a longer diameter of 800 to 900 paces, and a shorter of 500 to 600; but the sides of the crater, which are spoken of as perpendicular, are estimated to have been only from 150 to 200 feet high. We may probably infer, therefore, that the crater had become, in 1757, almost filled up by the fragmentary ejections of the long period of constant activity.

M. de Luc also informs us that the sea around the island had a yellow colour in places, and in others emitted fumes, the heat at the latter places being intolerable, and the fish of the sea killed. A little above the sea-level he found springs of warm water issuing from the beach and flowing into the sea; and around these spots the surface of the latter was covered with dead fish. It seems clear, therefore, that the fumaroles on the outside and on the submerged portions of the volcano, though similar in character, were more numerous and violent in their action than at the present day. This is, of course, no more than might be expected so shortly after a prolonged series of violent eruptions.

In 1768, Sir William Hamilton passed by Vulcano, but did not land on it; the volcano appears at this time to have lapsed into a state of quietness, for he compares it to the Solfatara of Naples, and his artist, Signor Fabris, gives a drawing, in which clouds of vapour are represented as steadily rising from it, in much the same manner as at the present day. Brydone assures us that in 1770, when he watched the island for a whole night, neither Vulcano nor Vulcanello emitted any glow of light, but only threw out volumes of white "smoke."

In 1771, according to Deville, and again in 1775, as recorded by Dolomieu, great eruptions of Vulcano took place. During the latter the great stream of obsidian on the north side of the cone is said to have been produced. Spallanzani, it is true, has thrown doubt on this statement of Dolomieu, on the ground that he could obtain no confirmation of the fact from the inhabitants of Lipari; it must be remembered, however, that Dolomieu visited Vulcano only six years after the eruption took place, while Spallanzani was not there till seven years later.

It seems to me extremely probable that the filling up of the crater, which had made so much progress at the time of M. de Luc's visit in 1757, had probably continued till 1775, when the liquid lava was able to overflow the crater-rim. Dolomieu's observations on the state of the crater in 1781 seem to be quite in accord with this view. The sides were then so steep that he was unable to enter the crater, but by means of a telescope he could distinguish two small pools, into which large stones slowly sank when rolled from the edge of the crater. That these were full of incandescent lava is proved by a fact that Dolomieu records, namely, that the vapours of Vulcano were by night resplendent with *placid flames* (evidently the reflected glow of a surface of lava like that of Stromboli) that rose above the mountain and diffused their light to some distance.

The great Calabrian earthquake of 1783, which was violently felt in all the Lipari islands, does not appear to have been attended by any change in the condition of Vulcano. But in March, 1786, according to the unanimous testimony of all the islanders, as carefully collected by Spallanzani only two years afterwards, a most violent eruption took place. At first a series of subterranean thunderings and roarings were heard over the whole of the islands, but accompanied in Vulcano by frequent concussions and violent shocks. Then the crater threw out a prodigious quantity of sand mixed with immense volumes of smoke and "fire" (incandescent matter). This eruption continued for fifteen days, and so great was the quantity of sand ejected, that the circumjacent places were entirely covered with it to a considerable depth. This eruption in its characters and effects may be justly compared with the Vesuvian outburst of 1822, which was witnessed by Mr. Scrope and so graphically described by him.

Two years after this great outburst of Vulcano, Spallanzani, to whose intelligent observations on this and other volcanos geologists are so greatly indebted, visited the island. Such was the terror inspired by the recent eruption, that he could not induce any

Liparote to accompany him into the crater. A resolute Calabrian, banished for his crimes to Lipari, was at last prevailed upon, by the offer of a large reward, to make the venture. Spallanzani describes the bottom of the crater as being oval in form, perhaps one-third of a mile in circumference, and covered with sand like the sides. The walls were almost perpendicular, and so high that Spallanzani judged them to exceed a quarter of a mile. It was only on the south-east side of the crater, where some of the materials had slipped from the sides, and formed a sloping talus, that access was possible.

In the centre of the bottom rose a small hill, about 45 feet in diameter, from every part of which a dense white smoke arose, its surface being encrusted with salts. On the west side of the crater-floor a mouth 30 feet in circumference gave off a column of dense white smoke with a loud roaring noise, and the explosions from this aperture had evidently blown away part of the adjacent crater-wall. Such was the heat and sulphurous stench proceeding from this "bocca" that it was impossible to approach it closely; its sides, however, could be seen to be coated with stalactites composed of sulphur and various salts. A spring of water, also depositing stalactites, was seen issuing at a height of about eight feet from the floor of the crater. All over the interior of the crater, and at many points around it, innumerable fumaroles poured forth jets of vapour, and in many places it was only necessary to stamp with the foot in order to produce fresh ones. The gas issuing from these apertures, the sides of which were intensely hot, sometimes extinguished a candle brought near them; but at other times the gas itself became ignited, and burned for several minutes with a bluish-red flame. At night several bluish flames could be seen rising from the bottom to the height of half a foot or sometimes higher; and these were most numerous and conspicuous in the central eminence.

Spallanzani describes the heat at the bottom as being so great as to burn his feet, causing him to seek refuge on the large blocks of lava scattered about. The odour of sulphuretted hydrogen was so strong as greatly to affect his respiration; it was in consequence very difficult to walk round the crater, and quite impossible to cross it near the middle. The action of the acid vapours on the fragments of glassy rock was very marked; and in one case Spallanzani was able to observe the commencement of change produced in a piece of black lava, which he jammed into the mouth of a fumarole and re-examined after the lapse of 32 days.

These clear descriptions of the great Italian philosopher enable us to refer without doubt to the grand eruption of 1786 the production of the existing vast crater of Vulcano; and this crater, it is probable, did not undergo any material changes, except in the number, position, products, and violence of discharge in its fumaroles, till the eruptions of 1873–4. That the signs of activity should have been much more marked two years after the great eruption than they afterwards became is no more than might have been expected. The amount of igneous action going on in 1788 was sufficient to cause an obscure red glow over the crater by night.

The southern and extinct portions of the island of Vulcano were inhabited and cultivated at a very early period. But during many of the more violent eruptions, which shook the whole island and covered it with thick deposits of ashes, the inhabitants would doubtless be driven away. This was certainly the case during the violent outbursts of the 18th century, when the island appears to have been wholly uninhabitable. At what period the people of Lipari found that the neighbouring volcano constituted, in its abundant chemical deposits, a great source of wealth, is not known. It is said, however, that at one time the collecting of these valuable products was abandoned, on account of the alleged injury done to the vines of Lipari by the sulphurous vapours. On the work being resumed by permission of the King of Sicily, furnaces for the purification of the sulphur are said to have been established in the Fossa Anticcha. The great accession of activity beneath the mountain, which heralded the series of outbursts of last century, made itself felt by an increase of heat in the soil, and abundant disengagements of suffocating gases, and this once more caused the cessation of the industry. As the terrors produced by the grand eruption of 1786 died away, and the crater began to gradually cool down, the inhabitants regained boldness sufficient to enable them again to visit the crater habitually, and at last to form habitations for themselves near the tempting but dangerous source of wealth, by excavating miserable homes in the old tuff cone of the Faraglione.

After the work of extracting the various chemical products had been carried on in a desultory manner for a considerable time, the crater was purchased a few years ago by a Glasgow firm for the sum of £8000, and regular chemical works established in the island. The collecting and preparation of the materials for exportation now employs about a hundred workmen, the whole of whom are Italians; but the necessary capital and machinery for carrying on the operations are supplied from this country.

Since the last grand eruption, and the lapse of the volcano into comparative tranquillity, its crater has been visited and examined by many geologists. Dr. Daubeny, who visited the island in 1824, observes:

"The operations of this volcano appear to be going on with much greater vigour than those of the Solfatara, and exhibit, perhaps, the nearest approximation to a state of activity during which a descent into the crater would have been practicable.

"Nor can I imagine a spectacle of more solemn grandeur than that presented by its interior, or conceive a spot better calculated to excite in a superstitious age that religious awe which caused the island to be considered sacred to Vulcan, and the various caverns below as the peculiar residence of the god.

"To me, I confess, the united effect of the silence and solitude of the spot, the depth of the internal cavity, its precipitous and overhanging sides, and the dense sulphurous smoke, which, issuing from all the crevices, throws a gloom over every object, proved more impressive than the view of the reiterated explosions of Stromboli, contemplated from a distance, and in open day."

At the present time the well-made road, leading by a series of zig-zags to the summit of the mountain, and the excellent viaduct over which this road is conducted into the interior—the trains of laden asses and mules passing along the same—and the groups of busy workmen scattered over the floor of this strange workshop, perhaps detract somewhat from the feeling of awe which the place would naturally inspire. What has been lost by the lover of the picturesque and wonderful, however, has been gained by the student.

Daubeny and Abich both availed themselves of the especially valuable opportunities afforded by Vulcano for making observations on the gases evolved by volcanic vents. M. Charles Ste.-Claire Deville and M. F. Leblanc, however, made a series of much more systematic experimental inquiries here in 1855-6. And still later, in 1865, M. Fouqué has continued these studies, and carried them much farther. To the results obtained by these eminent French chemists we shall have occasion to refer again in the sequel.

It is clear from the foregoing sketch of the history of Vulcano, fragmentary and imperfect though it necessarily is, that all the usual phenomena of a volcano in the *paroxysmal phase* are exhibited by it. As far as our accounts enable us to judge, it would appear that scarcely a century elapses without one or more violent outbursts; that sometimes the eruptions are continued with moderate violence during many weeks, months, or years, while at others the accumulated force is dissipated in a furious outbreak of comparatively short duration; and that, after these periods of intense activity, the mountain sinks into a state of comparative repose. All the usual phenomena of volcanic action are admirably illustrated in Vulcano—the shifting of the igneous vent along the line of subterranean fissure,—the formation, from time to time, of new craters,—the gradual filling up of these by the growth of small cones within them, leading as it would appear to grand paroxysmal outbursts, by which the crater is again relieved of its contents,—the decline of the volcano into the *solfatara stage*,—and the opening of parasitical vents, and sometimes of cones and craters, upon its flanks.

Since the last grand eruption in 1786, Vulcano has been in a state of almost complete repose, and even its gaseous emanations, appeared to be gradually declining in abundance and violence. Some writers had in consequence been somewhat rashly led to speak of it as a spent volcano. As if to make a protest against any such assumption, the volcano a little more than a year ago resumed its activity: and we may now perhaps infer that, having recovered from the exhaustion produced by its last terrific effort, during which the present vast crater was formed, it is now recommencing that series of moderate eruptions by which the crater will be once more filled and the vent so clogged that it can only be cleared by another great paroxysm.

Fortunately for geologists, Signor Ambrogio Pinconi, the very intelligent manager of the chemical works in Vulcano, kept a diary of his observations on the crater during the late outbursts, and several times, indeed, at considerable personal risk, ventured into it while the eruption was actually in progress. During the continuance of the eruptions, the operations of the labourers in the crater were of course suspended; but the first explosions were so sudden that, before the workmen could make their escape, three of them sustained serious injuries. From the entries in Signor Pinconi's journal, a copy of which now lies before me, and the notes which I made on the spot only two months after the eruption had ceased, I have drawn up the following account of it.

On the 7th September, 1873, signs of renewed activity began to be displayed in the crater of Vulcano, and a series of small eruptions took place within the crater. These continued with varying intensity and many interruptions until the 24th of October. On the 22nd January, 1874, the activity of the crater was renewed, and continued till the 5th of February.

During these eruptions rumbling sounds were heard, which were compared to a fusillade alternating with discharges of cannon. These noises were audible at Lipari, which is situated at a distance of 6 miles from the crater.

Several fissures were opened on the northern side of the bottom of the crater, and from these clouds of vapour were discharged and considerable numbers of stones thrown out. Some of these were of very considerable size; but the majority of them were, by repeated ejections, reduced to small fragments. Most of the stones fell back within the limits of the crater; but a few of them fell outside of it, and are seen scattered all over the sides of the cone. Some of these stones are 8 to 10 lbs. in weight; they are composed of highly siliceous rock (quartz-trachyte), and can be distinguished from the products of earlier eruptions by their pale-green colour and unweathered appearance. The fragmentary materials accumulated in great quantities around the orifices of ejection, and would doubtless have given rise to the formation of small cones on the bottom of the great crater, had not the large quantities of materials shaken down from the adjoining crater-wall caused the whole to assume the form of a great bank or talus, leaning against the northern side of the circular cavity.

On ascending to the top of this pile, which rises to the height of more than 100 feet above the bottom of the crater, I was able to see that from four still open mouths, ashes, lapilli and larger fragments of rock had been discharged, giving rise to the formation of a line of cones, the regularity of the building up of which had been greatly interfered with from the cause alluded to. From these open mouths considerable quantities of vapour were still (April 11, 1874) issuing.

Among the blocks of obsidian and quartz-trachyte, usually with highly contorted internal structure, which strewed the floor of the crater and had been ejected during the recent eruptions, were many which weighed several hundred-weights.

Considerable quantities of white ashes were ejected during these eruptions, and fell both in the islands of Lipari and Salina.

While these eruptions were taking place within the crater of

Vulcano, no change was detected in the state of the small fumarole which exists in the most recent of the craters of Vulcanello.

During the whole period of these eruptions, however, Stromboli was in a state of extraordinary activity, and it is said that outbursts of the two mountains occurred almost simultaneously.

On the other hand, I was assured that no correspondence could be discovered between the state of activity of Vulcano and the nature of the weather at the time.

Having sketched the history of Vulcano, so far as we have materials available for the purpose, it will now be interesting to consider its present state, and to discuss the origin of its various features.

As pointed out by Spallanzani, an admirable view of Vulcano and Vulcanello may be obtained from any of the high grounds in the southern part of Lipari. In order that the description of the island may be more readily followed, I have given, in Plate VII., a sketch taken from the mountain above Punta della Crepazza in Lipari, showing the great central cone of Vulcano, with its series of encircling older crater-rings in the distance, and Vulcanello and the Faraglione in the foreground.

The southern half of the island is made up of a series of semicircular ridges, each of which exactly resembles, on a small scale, the well-known Somma. These old crater-rings, for such they evidently are, consist of alternations of lava-streams and beds of agglomerate, the whole interpenetrated and bound together by innumerable dykes. On their outer sides these ridges slope gradually down to the sea; but towards the interior of the island they present bold precipitous cliffs. In these, as in the cliffs of Somma, the characteristic features of volcanic architecture can be admirably studied; and equal facilities are afforded to the geologist, where the sea has eaten into these old cones, as is especially the case on the south-west of the island. (See Fig. 4, page 15.)

These crater-rings, which culminate in Monte Saraceno (1581 feet in height), la Sommata, Monte Aria, and many other peaks considerably more than 1000 feet above the sea-level, are four in number, and are separated from one another by semicircular, flat-bottomed valleys, which are called Pianos. The whole of this southern part of the island is thickly covered with volcanic sand, produced in part by the decomposition of its rocks, but to which the ejections of the central cone are making constant additions. Consequently the island is almost a desert, a few fishermen only living on its southern shores, while some vine-growers maintain a hard struggle with the elements in sheltered nooks in the deep Pianos. No roads or even foot-tracks can be kept open, where every storm raises and redistributes the covering of volcanic sand; and in this the traveller sinks to the knees at every stride, while the few cultivated patches have to be protected from the dust-clouds by fences of reeds.

It is clear that the southern part of Vulcano has been the site of the formation of at least four volcanic cones, the central axes of which have been situated on a line directed N.W. and S.E.; and that the eruptions to which each new cone has owed its origin have, at the same time, destroyed the northern portion of the pre-existing one. The oldest crater-ring is composed of ordinary trachytic lavas, exhibiting all the characteristics and variations found among the products of the second period of eruption in the Lipari Islands; but the newer ones are found to present materials becoming continually more basic in composition, till at last they approximate to basalts and dolerites resembling those of Stromboli. The structure of this part of the island will be made clearer by a reference to the accompanying plan of the island, Fig. 10.

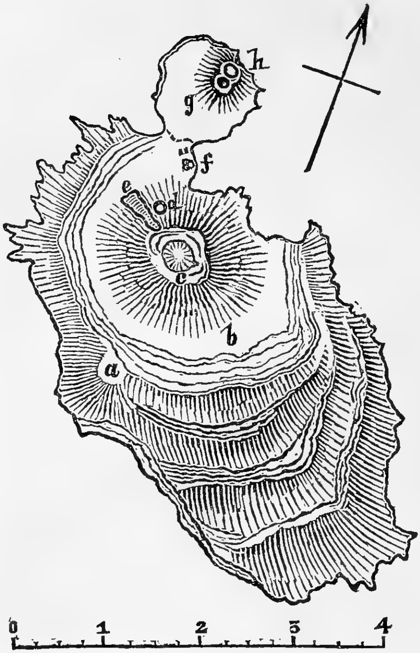


Fig. 10.—Plan of the Island of Vulcano, based on the map published by the Italian Government.—*a*. The four outer crater rings, culminating in Monte Saraceno. *b*. The Atrio surrounding the modern cone. *c*. The great crater. *d*. The smaller crater of the Fossa Anticcha. *e*. The obsidian lava-stream (of 1775). *f*. The Faraglione della Fabbrica. *g*. Lava-fields of Vulcanello. *h*. The cone of Vulcanello with its three craters.

Encircled by the four older crater-rings just described, and separated from them by a semicircular valley ("Atrio") deeply covered by volcanic sand, rises the active cone of Vulcano. This is not, as a glance at the sketch will show, a simple cone with a summit crater like that of Vesuvius, but a truncated conical mountain, in which the present crater occupies an excentric position. No one examining the upper part of the mountain can fail to perceive there the vestiges of a number of craters which have been successively formed and destroyed; and that the position of the central axis of eruption must have been subject to constant variation. These conclusions are confirmed, as we have seen, by those accounts of the state of the mountain in earlier times which have come down to us.

The highest point of the active volcano is situated on the north-east of the crater, and is 1266 feet above the sea-level. The lowest point of the crater rim, that over which the road is carried by which access is gained to the interior, is 882 feet high, while the floor of the crater is 532 feet above the sea-level.[1]

[1] There exists a remarkable discrepancy between some of the estimates of the height of the floor of the crater of Vulcano above the sea-level. Deville states it to be 837 feet, while Mr. Mallet gives it as only "a few feet," stating the depth of the crater to be from "1100 to 1200 feet." My own measurements with the aneroid were repeated on three different occasions, and varied only between 497 and 535 feet. The

The floor of the crater of Vulcano is about 200 yards in diameter; but its level area is much encroached upon by the talus that leans against its sides, and especially by the series of irregular cones which were thrown up on its northern edge during the late eruptions. The walls of the crater, which rise to heights of from 400 to 600 feet above its floor, are in their lower part vertical, but higher up slope outwards at an angle of about 45°. The diameter of the crater-rim is about 600 yards. The sides of the crater of Vulcano exhibit a series of admirable sections of the masses of agglomerate composed of materials of all sizes, often well stratified, and sometimes exhibiting the series of anticlinals all round the crater, which has been described by Mr. Scrope as so characteristic of the structure of volcanic cones. Some portions of lava-streams and dykes of vitreous lava can also be detected in the sides of the grand crater; but it is evident that the mountain has been mainly built up by fragmentary ejections.

The floor of the great crater of Vulcano, and also of the little crater of the Fossa Anticcha, to be hereafter noticed, is covered by a hard, compacted mass of pumiceous materials, which, when stamped upon or struck with any heavy body, gives forth a dull sound; this, as in the case of the well-known Solfatara of Naples, is vulgarly supposed to indicate the existence of vast cavernous hollows below the mountain. A much simpler explanation of the phenomenon has been suggested by Mr. Scrope (see Trans. Geol. Soc., 2nd series, vol. v.); and that there is no foundation for the popular notion is shown by the fact that many masses of compact tufaceous materials give forth, when struck, precisely the same *rimbombo* sound, even when situated at a distance from any crater.

All over the sides and bottom of the crater of Vulcano fumaroles are seen discharging acid vapours and gases. Many of these are of insignificant proportions; but very large ones exist on the north-western rim of the crater and at a number of points at its bottom. The sides of the fissures from which the vapours issue are sometimes red-hot; Fouqué found that zinc was melted by the jets of issuing gas, and Mallet that the temperature of the lips of the principal fissure was in 1864 "sufficient to melt brass wire, but not sufficient to fuse a similar wire of bronze." It is not surprising therefore to find that, with this elevated temperature, the more inflammable products of the fumaroles are ignited directly they reach the atmosphere. This would seem to be the origin of the feebly-luminous flames, usually of a blue colour, which are seen at night playing over some of the fumaroles; the existence of these will not of course be thought to give any support to the popular notion of masses of red flame rushing out of a volcanic crater during eruption, which has been clearly demonstrated to be an optical illusion. Around all the larger fumaroles are crusts of salts, usually of a white or pale

estimate given in the text is that of M. Salino, and appears to be derived from the official survey. Possibly some irregularity in the action of Mr. Mallet's barometer may account for the very inaccurate results which he was so unfortunate as to obtain, not only on this occasion, but in other observations about the same time at Stromboli.

yellow colour, but sometimes exhibiting a bright red tint, communicated to them by the sulphide of arsenic (Realgar).

The distinguished chemists, who at the instance of the French Academy have studied the gases discharged from volcanic vents, have accumulated a large body of valuable information on this interesting subject. Vulcano affording such remarkable facilties for their investigation, has received much attention from MM. Charles Sainte-Claire Deville, Leblanc and Fouqué. Their conclusions it would be impossible to detail, much less to discuss the bearings of upon geological questions, in the present sketch. Some of the more important facts obtained may, however, be briefly noticed.

The elements which have been detected among the gaseous emanations of Vulcano are as follows:—oxygen, hydrogen, nitrogen, chlorine, iodine, sulphur, selenium[1] (first detected by Stromeyer in 1825), phosphorus, arsenic, and boron; and the presence of bromine is suspected though not proved. The most remarkable circumstance is the abundance of boron in these emanations; this element not being an ordinary product of volcanic action, though found so abundantly in the hot springs of Tuscany.

It has been clearly shown that the nature of the gases evolved varies with the temperature of the fumaroles. This fact is illustrated by the following table, in which I have placed side by side a number of the analyses made by M. Fouqué:

	a.	*b.*	*c.*	*d.*	*e.*	*f.*
Sulphurous and Hydrochloric acids.	73·80	66·0	34·0	27·19	7·3	0·0
Carbonic acid............	23·40	12·0	28·0	59·62	68·1	63·59
Sulphuretted Hydrogen	traces	10·0	12·0	0·0	10·7	traces
Oxygen	0·52	2·4	4·8	2·20	2·7	7·28
Nitrogen.................	2·28	9·6	21·2	10·99	11·2	29·13

a. was from a strongly acid fumarole, with a temperature of 360° C., which deposits sulphide of arsenic, chloride of iron, and chloride of ammonium towards its centre, and boracic-acid and sulphur at greater distances.

b. was from a similar fumarole, but with a temperature of only 250° C.

c. was similar to *a* and *b*.

d. deposited similar salts to the former, but its temperature was only 150° C.

e. was from a slightly acid fumarole, with a deposit of chloride of ammonium, sulphur, and boracic, acid, and a temperature of only 100° C.

f. was similar to *e*.

Sulphur appears to be deposited round volcanic fumaroles through

[1] The mixture of sulphur and selenium deposited here received from Haidinger the name of "Volcanite."

the action of sulphurous acid and sulphuretted hydrogen on one another. The production of the large quantities of chloride of ammonium can scarcely be explained, however, unless we admit with Daubeny that nitrogen, under conditions of high temperatures and pressures, exhibits a chemical activity, very different indeed from its inert character under ordinary circumstances.

The quantity of volatile matter issuing from the fumaroles of Vulcano varies from day to day, and new fissures are being continually opened, while old ones become closed. Signor Pinconi assured me that, after the recent eruption, the fumaroles discharged with enormously augmented violence, and that they produced, at the time of my visit, at least four times the quantity of salts deposited before the eruption. Two condensing chambers had just been erected over the largest fumarole for the artificial condensation of the vapours, but sufficient time had not elapsed to test the success of this method of collection. At present, the crusts composed of boracic-acid, sulphur, and sal-ammoniac are dug up round the fumaroles and conveyed to the outside of the crater by an excellent road carried over a viaduct. The sulphate of alumina, which is also largely collected, is produced by the action of the acid vapours on the pumiceous tuffs and agglomerates composing the mass of the mountain. At the "fabbrica," near the Faraglione, the products are roughly separated by simple machinery, sent from England for the purpose; but the salts are forwarded to this country for purification.

The cone of Vulcano is made up of agglomerates, often well stratified; the materials being much altered through the permeation of the mass by acid gases and vapours, and often exhibit brilliantly variegated tints. Half way down the slope of the mountain, on its northern side, is the little crater called Fossa Anticcha or Forgia Vecchia, the floor of which has a diameter of about 60 yards, while acid vapours are discharged by several fumaroles at its sides. In the sides of this crater, and in a great fissure near it, the characteristic quaquaversal dip of the materials in volcanic cones is well exhibited. The ejected materials are often seen forming beds dipping at angles of from 25° to 30°. (See Fig. 11.) The date of the formation of the crater called the Fossa Anticcha is quite unknown. It is clear that it existed at the time of Spallanzani's visit to the island, and he imforms us that at some earlier period the collection and purification of the products of the mountain had been carried on in it.

The lava-stream on the north-west side of the cone of Vulcano is composed of obsidian passing into Liparite, and exactly resembles those of the last period of eruption in the adjacent island of Lipari, which were described in the last chapter. Two points in connexion with this lava-stream are, however, worthy of especial notice. Firstly, although of great thickness, it has evidently consolidated on a slope of 35°, thus affording a striking illustration of the baselessness of the opinions maintained by Elie de Beaumont and M. Dufrenoy on this subject, by means of which they sought to support the exploded theory of "Elevation-craters." Secondly, in its wonderfully contorted internal structure, its rent and rugged surface, and especially in the manner in which, on reaching a somewhat less steep slope, its materials have been piled up into a high ridge, this current affords a most striking illustration of the extremely imperfect state of fluidity in which the vitreous lavas of Lipari were poured forth. (See Fig. 11.)

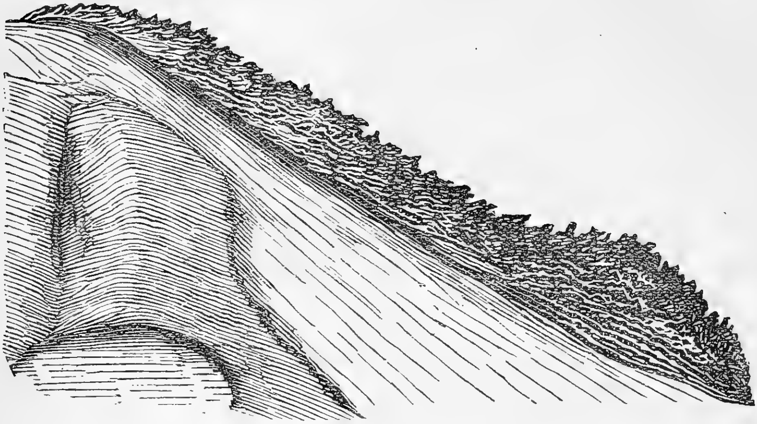


FIG. 11.—Profile-sketch of the obsidian lava-stream (of 1775) on the north-west side of the cone of Vulcano, with the stratified tuffs seen in the side of the Fossa Anticcha below.

The present fresh appearance of this lava-stream, uncovered as it remains by fragmentary ejections, is strongly confirmatory of the very recent date, that of 1775, which Dolomieu assigns to it. On the south side of the cone of Vulcano is another lava-stream, evidently of far older date, and almost completely buried under ejected materials. All the solid ejections of the existing cone of Vulcano appear to have consisted of the most highly acid rocks—Liparite, obsidian, and pumice—like the materials of the later eruptions in Lipari.

Between Vulcano and Vulcanello rises the mass of volcanic tuffs, evidently the denuded fragment of a cinder cone, which is known as the Faraglione. In a grotto in this mass, the sides of which continually drop with water abounding in acids and various salts, the most beautiful stalactites of sulphate of alumina, and various compounds of lime, iron, and occasionally of copper are formed. In this grotto I collected the brillant crystals belonging to the cubic system, of the hydrated compound of ferric and ferrous sulphates, called "Voltaite," a mineral first discovered by Scacchi in the Solfatara of Naples. Around the Faraglione, fumaroles discharging vapour with sulphuretted hydrogen and carbonic acid gases at an elevated temperature occur, while others are found giving off the latter gas only at the ordinary temperature of the atmosphere; these latter have been justly compared by Deville to the Grotto del Cane, at the Lago Agnano, near Naples.

The isthmus joining Vulcano and Vulcanello, and composed of fragmentary matters ejected by the volcanos, appears to have been formed in the sixteenth century. It is doubtful if Vulcanello be really the island which was thrown up in the second century before Christ. Its three craters have evidently been formed at very different periods (see Fig. 6, p. 58), and the newest of them still contains one or two active fumaroles; in the time of Spallanzani it was clearly in a much more active state. Some of the older lavas of Vulcanello were of basic composition.

Such is the structure of Vulcano, which exhibits, as we have seen in its various features clear evidences of a vast series of paroxysmal eruptions, repeated, at not very distant intervals, during the whole of the historical epoch.

In our next chapter we shall describe Stromboli, a volcano offering in its features, its modes of action, and its products, some remarkable and very suggestive points of contrast with Vulcano.

(To be continued in our next Number.)

III.—A Chapter in the History of Meteorites.

By Walter Flight, D.Sc., F.G.S.,
Of the Department of Mineralogy, British Museum;
Assistant Examiner in Chemistry, University of London.

(*Continued from page* 80.)

Meteoric Irons found August, 1870.—Ovifak (or Uigfak) near Godhavn, Kekertarssuak or Island of Disko, Greenland [Lat. 69° 19′ 30″ N.; Long. 54° 1′ 22″ W.][1]

The interesting story of the discovery of these enormous masses by Prof. Nordenskjöld is already known to the readers of this Magazine through a translation of his original memoir. While exploring in Danish Greenland in 1870, his attention was directed to the possibility that meteorites might be met with in Disko Island, by the accidental discovery of a block of meteoric iron in some ballast which had been taken in at the old whaling-station at Fortuna Bay, near Godhavn, and he urged the Greenlanders to search the district for masses of that metal. He proceeded to explore Omenak

[1] A. E. Nordenskjöld. Redogörelse för en Expedition till Grönland år 1870. *K. Vet.-Akad. Förh.*, 1870, 873. (See translation in Geol. Mag., IX. 289, *et seq.*) —D. Forbes, *Abstract Geol. Soc.*, No. 238, November 8th, 1871. *Chem. News*, November 17th, 1871.—A. E. Nordenskjöld. Remarks on Greenland Meteorites. *Abstract Geol. Soc.*, December 20th, 1871.—T. Nordström. *Ofv. Vet. Akad. Förh.*, 1871, 453. See also Geol. Mag., VIII. 570, and IX. 88.—A. E. Nordenskjöld. Les Météorites. *Revue Scientifique*, 1872, ii. [2], 128.—G. A. Daubrée. *Compt. rend.*, lxiii. 1268. *Compt. rend.*, lxxiv. 1542. *Compt. rend.*, lxxv. 240. E. Ludwig. *Min. Mitt.*, 1871, i. 109.—E. Hébert. Séance Soc. Geol. de France, February 5th, 1872. *Revue Scientifique*, i. [2], 858.—E′. de Chancourtois and M. Jennatez. Séance Soc. Geol. de France, February 19th, 1872. *Revue Scientifique*, i. [2], 905.—G. A. Daubrée.—Séance Soc. Geol. de France, May, 20th, 1872. *Revue Scientifique*, i. [2], 1169. *Amer. Jour. Sc.*, iii. 71 and 388.—F. Wöhler. *Nachricht. K. Gesell. Wiss. zu Göttingen*, 1872, No. 11, 197. *Pogg. Ann.*, cxlvi. 297. *Ann. der Chem.*, clxiii. 247. *Nachricht. K. Gesell. Wiss. zu Göttingen*, 1872, No. 26. *Ann. der Chem.*, clxv. 313.—G. Rose. *Zeit. Deutsch. Geol. Gesell.*, xxiv. 174.—G. von Helmerssen. *Zeit. Deutsch. Geol. Gesell.*, xxv. 347.—C. Rammelsberg. Ueber die Meteoriten (*Samm. wiss. Vorträge*), pages 14 and 18.—C. W. Blomstrand. *Ber. Deutsch. Chem. Gesell.*, iv. 987.—G. Nauckhoff. *Svenska Vet. Akad. Handl.*, 1872, i. No. 6. *Ber. Deutsch. Chem. Gesell.*, vi. 1463. *Mineralogische Mittheilungen*, 1874, 109.—G. Tschermak. *Mineralogische Mittheilungen*, 1874, 165. *Der Naturforscher*, 1874, Nos. 49–52.—For a map of Disko see *Geographical Mag.*, February, 1875.—J. Lawrence Smith, *Compt. rend.*, lxx. 301.

and other islands north of Disko, and, on his return to Godhavn at the end of August in the same year, not only learned from the Greenlanders that masses such as he sought for had been found, but he was shown a specimen of meteoric iron in confirmation of their statement. They were discovered, not at Fortuna Bay, but further eastward along the shore, at Ovifak, between Laxe-bugt[1] and Disko fjord, a spot than which there is none more difficult to reach along the whole of the coast of Danish Greenland, as it lies open to the south wind, and is inaccessible in even a very moderately rough sea. Nordenskjöld at once chartered two whale-boats, manned by Greenlanders, and set sail for Ovifak, where, the sea being calm, they were able to land, and the stone at which they lay to proved afterwards to be the largest block of meteoric iron that they were to discover.

As the readers of this Magazine are already familiar with the description which Nordenskjöld gives of the condition under which these masses are found, we may break off here to consider the more recently published report of Nauckhoff, the geologist of the expedition of 1871, of the peculiar geological characters of the rocks at Ovifak (Blåfjell, or Blue Cliffs) with which they are associated.

The surface of the south-western and western portion of the island of Disko is composed of basalt, which extends as far as Smith's Sound, and was probably erupted in Miocene times. In only a few points of the island, Godhavn, the islets of Fortuna Bay and Nangiset, the primitive rock is observed. It consists for the most part of slaty gneiss, passing over in some places into mica-schist and often traversed by veins of pegmatite. Granite was nowhere seen.

Immediately overlying the gneiss is a basalt breccia of dark blackish-green colour, some two hundred feet in thickness. In places the large angular fragments are cemented together with calcite; as a rule, however, they are so small that the rock at some distance appears homogeneous. Few cavities are observed, and they are usually filled with calcite, rarely with zeolites. Above the breccia lies a bed of basalt-wacké of rust-brown colour, and with amygdaloidal structure, the cavities containing apophyllite, chabasite, levynite, stilbite, desmine, mesotype, analcime, and other zeolites. Over this again rises a bed of basalt of vast thickness, sometimes attaining one thousand feet, and of a dark greyish green hue; it occurs not unfrequently in vertical regular six-sided columns. The texture is generally crypto-crystalline, though exhibiting in places the characters of anamesite and dolerite; the few cavities are filled with chalcedony, rarely with zeolites. At Ovifak the cliffs rise to a height of 2,000 feet above the sea-level. The upper portion consists of compact dark-coloured basalt. Proceeding downwards on the nearly vertical face, we see thick beds of red-wacké and basalt-clay, until already at mid height the face is hidden by vast screes of large and small fragments of basalt. Where the cascades of surface-water have removed the finer portions of the talus, and the face can be inspected to greater depths between the larger blocks of basalt, the basalt-wacké is seen which overlies the breccia.

[1] See Geol. Mag., 1872, Vol. IX. Pl. VII. In this map two bays called Laxebugt are given; the one mentioned above is situated to the north of Disko fjord.

On the shore below these screes between high and low-water, and within an area of about fifty square metres, twelve large and many small iron masses were found. The six largest weigh respectively 21,000 kilog., 8,000 kilog., 7,000 kilog., 142 kilog., 96 kilog., and 87 kilog.

Thanks to the kindness of Prof. Nordenskjöld, I am enabled to give a representation (Plate IV.[1]) of the largest mass (about 19 English tons in weight), which is now preserved in the hall of the Royal Academy at Stockholm. The second block, weighing about nine tons, has, as a compliment to Denmark, on whose territory the meteorites were found, been presented to the Museum of Copenhagen. Another of the masses, weighing 195 lbs. 8 oz., is preserved in the British Museum.

For the earlier account of the discovery of these masses the reader is referred to Nordenskjöld's memoir,[2] and Nordström's paper. The expedition of that year, 1870, having no means of bringing such vast masses to Europe, a new expedition was equipped by the Swedish Government in the following spring, consisting of the gunboat "Ingegerd," Capt. F. W. von Otter, and the brig "Gladan," under the command of M. von Krusenstern, who brought the meteorites to Denmark in September, 1871.

Nauckhoff in his paper draws attention to one remarkable block, about 200lbs. in weight, which lay three feet below high-water. On the under-side it was covered with basalt grains, cemented together with hydrated oxide of iron, and consisted of coarsely crystalline iron, containing much carbon, and which readily weathered.

Sixty-five feet N.E. of the spot where the largest block lay, a ridge of dark brown basalt-like rock comes to the surface. Through its superior hardness it has withstood the denudation better than the loose basalt-wacké on either side of it. It is soon lost to sight, but reappears to take a direction towards the spot where the large iron lay. The rock forming this ridge resembles ordinary compact basalt. It is of finely granular texture. Near the margin it becomes crypto-crystalline, and is seen under the microscope to consist of labradorite, greenish-brown augite and black grains of magnetite. It will be found, when we come to speak of the analysis of the rocks accompanying this iron, to accord in composition with the basalt itself. It differs from it, however, in the presence of two accessory constituents which are disseminated through the parts forming the edge of the ridge, and are: a greenish hydrated ferrous silicate resembling hisingerite, and a yellowish brown iron sulphide. The analyses of the former mineral, it will be seen in the sequel, show that it is not identical with the chlorophæite so often occurring in basalt; the sulphide completely accords in composition with the troilite of meteorites. The columnar structure, so often found in basalt, was not noticed, the cracks occurring near the sides appearing to be all parallel to the margin. The surface of a freshly broken fragment displays peculiar smoothness and lustre. On the

[1] This Plate will appear in the April Number with Part IV. of Dr. Flight's paper. —Edit. Geol. Mag.

[2] Geol. Mag. 1872, Vol. IX. pp. 461, 462, and Plate VIII.

east side of this ridge, and in the solid rock, a piece of much-weathered iron was found inclosed by Nauckhoff; while another member of the expedition, Mr. J. Steenstrup, detected metallic iron on the west side of the ridge. The analysis of this iron, apparently that which was analysed by Lindström, will be referred to later on. While blasting this basalt, a rock was hit upon which was at once seen to differ considerably from the matrix. It consists of a greenish ground mass, inclosing spangles and grains of iron, and occurs in rounded masses that are separated from the basalt by a coarsely crystalline greenish shell, about 20 mm. thick as well as by an outer rusted brown crust. The boundaries of these masses were well defined; in no instance were they detected passing over into the basalt.

The masses of iron lying in the basalt ridge usually had an ellipsoid form and a rusted crust, that allowed of their being easily detached from the basalt. Nauckhoff succeeded in removing six lumps, the aggregate weight whereof was 150 lbs. This iron is hard and crystalline, exhibits Wiedmannstättian figures, and is in every respect like that of the large loose blocks. Moreover, like them, it unfortunately possesses the property of exuding a yellow liquid (ferrous chloride), and of weathering away. It was noticed that these inclosed masses had their major axes parallel to the direction of the ridge, and that they were in a way connected with each other by little veins of weathered iron.

Nordenskjöld states that the large free blocks of metal had a tombac to rusty-brown colour, and, when found, exhibited metallic lustre on parts of their surface. Here and there, fragments of basalt, similar to that of the ridge, were found adhering to them. The inner parts contained none of the rock, and his analyses detected the presence of little silicic acid. They were strongly polar, the upper surface attracting the north, the lower side the south pole of the magnetic needle.

The iron of the large masses is crystalline and brittle, so that pieces can readily be removed with a hammer; the metal of the ridge is tougher, and has a rougher fracture. The presence of troilite was rarely detected in the detritus; a few black magnetic grains were met with which, by their octahedral faces, were recognized to be magnetite.

The characters of the polished sections of the different masses differ greatly: in some the surface shows rounded areas of varying brightness and shades of colour, with parts of a brassy yellow (troilite); others are more homogeneous, or appear to be made up of fine prisms of "carburetted nickel-iron." Some, not all, exhibit figures when etched.

Though containing little sulphur, the Greenland irons, since they have been brought to Europe, have shown a marked tendency to crumble to pieces. On the shore at Ovifak, sometimes exposed to the wash of the waves, sometimes left high and dry, but preserved at the constant temperature of the sea, which varies little throughout the year, the masses apparently underwent little change. Already during the passage, however, many fragments crumbled away, and when unpacked at Stockholm two months later, and placed in a room of ordinary temperature, others broke up into a reddish brown powder. A freshly fractured lustrous surface of one of the masses commenced in one corner to rust, expand and crumble away; while the remainder experienced no change, till at length the oxidation extended into the interior and the whole fell to pieces. In a hermetically sealed glass tube the iron is preserved unchanged; but in another tube with a fine crack oxidation continued. In alcohol no change takes place; in air, dried by sulphuric acid, the change is greatly impeded. Attempts to preserve them by coating them with varnish were of slight avail. The cracking is caused by dilatation, and takes place with such force that masses of metal, on which chisel and saw were without effect, are broken and bent out of shape during oxidation.

Nordenskjöld found that a fragment of the largest iron, when heated to redness, gave off more than 100 times its volume of a gas which had a bituminous smell. It was evidently gas not simply occluded by the metal, but was produced by the decomposition of "the organic matter in the meteorite," through the reducing action of those compounds on the oxide of iron associated with them. When such iron is treated with mercury chloride but little gas is evolved; in aqua regia it dissolves, leaving in some cases a carbonaceous residue, in others very little residue of any kind; by the action of hydrochloric acid a gas is given off which has a penetrating odour resembling that of some hydrocarbon. By treatment with acid a humus-like compound appears to be generated, which is soluble in ammonia, insoluble in acid, and can be oxidized only with difficulty by long boiling with very strong acids.

In Nordenskjöld's paper are given the earliest analyses of these irons:

I. Fragment of one of the large iron masses: this specimen evolved more gas than II. and III. Specific gravity = 5·86—6·36. Analysed by Nordenskjöld. II. Fragment of iron, more compact and less crystalline than I., probably from the basalt ridge. Small grains were observed to be malleable. The specimen from which this was taken subsequently crumbled away. Specific gravity = 7·05—7·06. Analysed by T. Nordström. III. Fragment of iron from the basalt ridge, which exhibited well-marked Wiedmanstättian figures. In external appearance this iron exactly resembled II. Specific gravity = 6·24. Analysed by G. Lindström.

	I.	II.		III.
Iron	84·49	86·34		93·24
Nickel	2·48	1·64		1·24
Cobalt	0·07	0·35		0·56
Copper	0·27	0·19		0·19
Phosphorus	0·20	0·07		0·03
Sulphur	1·52	0·22		1·21
Chlorine	0·72	1·16		0·16
Alumina	trace	0·24		—
Lime	trace	0·48		—
Magnesia	0·04	0·29		trace
Potash	trace	0·07		0·08
Soda	trace	0·14		0·12
Silicic acid	trace	0·66		0·59 (Silicic acid and Insoluble portion)
Insoluble portion	0·05	4·37		
Carbon, Organic Matter, Oxygen, and Water	10·16	3·71	Carbon	2·30
			Hydrogen	0·07
	100·00	99·93		99·79

Nordström analysed the carbonaceous residue of the compact iron

II., after digestion with double chloride of copper and sodium, and iron chloride, and found, when a quantity of ash is deducted, that it is composed of:

Carbon	63·59	......	63·64
Hydrogen	3·26	......	3·55
Oxygen (by difference)	33·15	......	32·81
	100·00		100·00

These numbers yield no satisfactory atomic ratios, and it is not improbable that the carbon is present in two allotropic modifications, as well as a constituent of a complex organic compound.

In 1872 two interesting papers were published by Wöhler on the results of his examination of this iron, especially that from the ridge. The specimen he chose for examination came from a vein of metal several inches wide and some feet in length, which was inclosed in a rock "that presents a marked difference in composition from the basalt breccia whence it protrudes." He describes this iron as bearing a close resemblance to grey cast iron; it has a bright lustre, is very hard, is quite unalterable in air, and has a specific gravity = 5·82. Nordenskjöld, as we have seen, extracted gas from the metal of the larger masses by heating it. Wöhler finds that the iron of the vein evolves more than one hundred times its volume of a gas that burns with a pale blue flame, and is carbonic oxide, mixed with a little carbonic acid. The "iron," in fact, contains a considerable amount of carbon, as well as a compound of oxygen; and, according to Wöhler, can at no time have been exposed to a high temperature. After it has been heated, the iron becomes brighter, and, though more soluble in acid, it still leaves a carbonaceous residue. A fragment heated in dry hydrogen, with a view to determine the amount of oxygen present, formed a quantity of water, and lost 11·09 per cent. of its weight. "It contained, in other words, 11·09 per cent. of oxygen." It is not stated whether the water corresponded in weight to that amount of oxygen. Hydrochloric acid acts but slowly and imperfectly on this metal, evolving first sulphuretted hydrogen, and then hydrogen possessing the odour of a hydrocarbon, and leaves a black granular magnetic powder, which, though insoluble in cold acid, generates on the application of heat a gas with a strong odour of a hydrocarbon, leaving a residue of amorphous sooty carbon and slightly lustrous graphitic particles. In iron chloride the "iron" dissolves without evolution of gas, about 30 per cent. of a black residue remaining, which, after having been dried at 200° C., lost by ignition in hydrogen 19 per cent. of its weight, water being produced. It is now very readily attacked by acid, evolves sulphuretted hydrogen, and gives a residue of nearly pure carbon in powder or in graphitic scales. Iron chloride and acid appear, therefore, in the main, to remove the free metal only, and to be without action on the compounds with sulphur and oxygen. The ultimate composition of the specimen he analysed is as follows:

Iron	80·64	Sulphur	2·82
Nickel	1·19	Carbon	3·69
Cobalt	0·47	Oxygen	11·09
Phosphorus	0·15		100·05

Wöhler was disposed to regard the oxygen, constituting so considerable a portion of an apparently metallic mass, as present in the form of a diferrous oxide, Fe_2O, were it not that, according to this view, there would be no iron provided for combination with the sulphur and carbon. As, however, Nordenskjöld found magnetite in or near other Ovifak irons, Wöhler regards that constituting the veins as an intimate mixture of magnetite, of which there would be 40·20 per cent., with metallic iron, of which there would then be 46·60 per cent., the sulphide, carbide, and phosphide, as well as the alloys with nickel and cobalt, and some carbon in isolated particles. The latter probably undergo no change when the magnetite and carbide, by the action of heat, generate carbonic oxide.

A specimen of the iron from the basalt has also been investigated by Daubrée; he describes it as having a metallic lustre and being nearly black. He found its composition to be:

	I.
Iron in the free state	40·940
Iron in combination	30·150
Carbon in the free state	1·640
Carbon in combination	3·000
Nickel	2·650
Cobalt	0·910
Phosphorus	0·210
Arsenic	0·410
Sulphur	2·700
Silicium	0·075
Nitrogen	0·004
Oxygen	12·100
Water (hygrometric)	0·910
Water in combination	1·950
Chromium, Copper, etc.	1·010
Calcium sulphate, chloride, etc.	1·354
	100·013

In his second paper he gives analyses of two more specimens:

II. Light grey iron, possessing metallic lustre. It is not homongeneous, as it might be assumed to be from its lustre and colour. When crushed in a mortar, it is divided into two parts: the one crumbles to fine powder, the other is flattened into plates, requiring much trituration to break them up. III. Metallic grains mechanically separated from the rocky portion in which they were distributed. These spherules exhibit figures, when etched, and contain silicate distributed in very fine pieces throughout their mass; in one rounded fragment the silicic acid of this silicate amounted to 11·9 per cent. of the total constituents.

	II.	III.
Iron in the free state	80·800	61·990
Iron in combination	1·600	8·110
Carbon in the free state	0·300	1·100
Carbon in combination	2·600	3·600
Silicium	0·291	—
Water	0·700	—
Calcium chloride	0·233	0·146
Iron chloride	0·089	0·114
Calcium sulphate	0·053	0·047
Copper	trace.	trace.

It will be seen that specimen III. is not less rich in carbon than I., and that specimen II. also contains a considerable quantity.

Specimen I. is distinguished from II. by a large proportion of combined iron. By treatment with alcohol, calcium chloride was extracted and determined in I.; with cold distilled water, the soluble salts were removed from II. and III. I. contains more lime sulphate and less chloride than II. and III.

These meteoric masses are distinguished by the amount of carbon, free and combined, which they contain; by the presence in them of a large proportion of iron in combination with oxygen, but in what state of oxidation is not clearly ascertained; and by the occurrence of soluble chlorides and sulphates, especially calcium sulphate, throughout their structure. No salt of potassium has been detected in them, nor, which is very remarkable, has sodium chloride been found, although carefully sought for. The intimate distribution of these salts through the Ovifak iron is certainly an indication that they must be numbered among the original constituents of these meteorites.

Daubrée noticed that specimen II. showed a marked tendency to absorb water and to rust away; a few days sufficed to make this apparent. The local nature of the oxidation he attributes to the irregular distribution of the deliquescent salts. Among these compounds, instead of iron chloride, to the action of which the decay of meteoric iron has usually been ascribed, calcium chloride appears to play the most prominent part. In support of this view it may be remarked that No. II. iron, the one most liable to change, is that containing the greatest proportion of this salt, the amount being six times that met with in No. I. iron.

Calcium and magnesium sulphates were noticed by Daubrée to form constituents of the Orgueil Stone, and the latter salt is also present in the aerolites of Kaba and Alais. All these are carbonaceous meteorites. May the calcium sulphate of these irons, as well as that of the above-mentioned aerolite, be a product of the oxidation of a calcium (magnesium) sulphide such as occurs in the meteorite of Busti, which stone also contains, among other constituents, augite and metallic iron?

The greater stability which these masses exhibited so long as they were in polar latitudes is no doubt due to the reduced tension of aqueous vapour; had they fallen in regions further south and been exposed to a milder climate, they would without doubt have long since fallen to powder.

In his second paper Wöhler points out the probability of the No. II. iron which Daubrée examined being of the same kind as that which he himself analysed. He remarks that, although Daubrée found this variety of the metal to show a tendency to oxidize even in a few days, his specimen had remained bright and unchanged after it had been a year in his collection.

Nauckhoff, whose exhaustive examination of the rocks associated with the Ovifak irons we shall immediately turn to consider, analysed the spangles and spherules which can be removed by a magnet from the rock that occurs in rounded masses in the basalt ridge, and of which the composition is given in the table of his analyses under III. Some of these spangles could be pulverized only with difficulty, and were readily flattened out; the spherules, though so hard that a sharp steel file would scarcely touch them, were easily crushed. They had the following composition:

Iron	58·25	Phosphoric acid	trace.
Nickel	2·16	Alumina	1·45
Cobalt	0·30	Nickel and Cobalt oxides	0·44
Copper	0·13	Magnesia	0·33
Hydrogen	0·28	Lime	0·50
Carbon	1·64	Soda	0·09
Sulphur...	0·16	Potash	trace.
Chlorine	0·16	Residue...	6·07
Magnetite	30·42		
Silicic acid	0·26		102·64

In the basalt of the ridge, of which an analysis is given under II. in the same table, a compact, very brittle, yellow, or slightly brown mineral occurs in thin flakes, sometimes in nodules of the size of a pea; it is invariably penetrated and usually surrounded by a mineral resembling hisingerite, to which attention will presently be directed. The mineral has a hardness of 5 to 5·5, and easily fuses before the blowpipe with evolution of sulphurous acid to a magnetic regulus. It has the composition:

			Equivalent Ratios.	
Iron...	52·94 ...	57·91 ...	2·068	2·258
Nickel	5·06 ...	5·53 ...	0·190	
Copper	trace. ...	trace. ...	—	
Sulphur	33·41 ...	36·56 ...	2·285	
Silicate	8·59 ...	— ...	—	
	100·00	100·00		

These numbers give the formula (Fe,Ni) S, or that of the iron (nickel) monosulphide or troilite, which has hitherto only been met with in meteorites.

Intimately associated with the troilite, and evidently a product of its oxidation and further alteration is the mineral already mentioned, the fresh fracture of which is of a light olive-green colour, that by exposure to the air soon becomes brown, and after some days turns quite black.

Its specific gravity is 2·919, and composition:

		Oxygen.
Silicic acid	31·70	16·90
Iron sesquioxide	51·49	15·44
Iron protoxide...	3·81	0·85
Water	15·56	12·05
	100·56	

These numbers indicate the formula:

$$FeO,SiO_2+3(2Fe_2O_3.3SiO_2)+14H_2O$$

as that of the mineral. Nauckhoff, however, draws attention to the rapidity with which the oxidation of the pulverized mineral takes place: five days after the analysis was made the per-centage of iron protoxide in another portion had fallen to 3·47, and after three weeks to 1·55. The original unchanged mineral was probably a hydrated ferrous silicate.

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

IV.—On the Gault *Aporrhaïdæ*.

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

(PLATE V.)

(*Continued from page* 56.)

Addenda and Notes to Group 1.

Since the appearance of the first part of this paper, I have had, through the kindness of M. Deshayes and Prof. Gaudry, an opportunity of examining the original specimens in D'Orbigny's cabinet in the Jardin des Plantes, and am enabled to add the following to the list of species included in Group 1. They are all in the Prodrome :—

A. Aonis, D'Orb., from the Chalk.

A. Mailleana, D'Orb., *id.*

A shell of larger size than *A. retusa* or *A. Fittoni,* with very angulated whorls, one strongly developed keel visible to the apex of the spire, a second keel visible on the last whorl only :—wing unknown.

The figure in the Pal. Fr. does not resemble in its characters the specimen in the cabinet numbered 6238, *which is identical with one of the two Grey Chalk species mentioned last month as undescribed.* If the figure is correctly drawn, there are two species under this name :—

A. (*Pt.*) *marginata,* D'Orb.

Some of the specimens are probably *A. retusa,* but others are more globular, and are regularly and deeply striated, resembling the second undescribed form mentioned from the Grey Chalk. Any definite opinion as to their identity must be reserved until better specimens are procured.

The figure in D'Orb. Pal. Fr., pl. 217, fig. 2, is much larger than any in the cabinet, which do not exceed the dimensions of the test of *A. retusa.*

A. Moutoniana, D'Orb., and *A. provincialis,* D'Orb., from the Neocomien of Escragnolles and Var, are probably the *A. Fittoni* of the Lower Greensand.

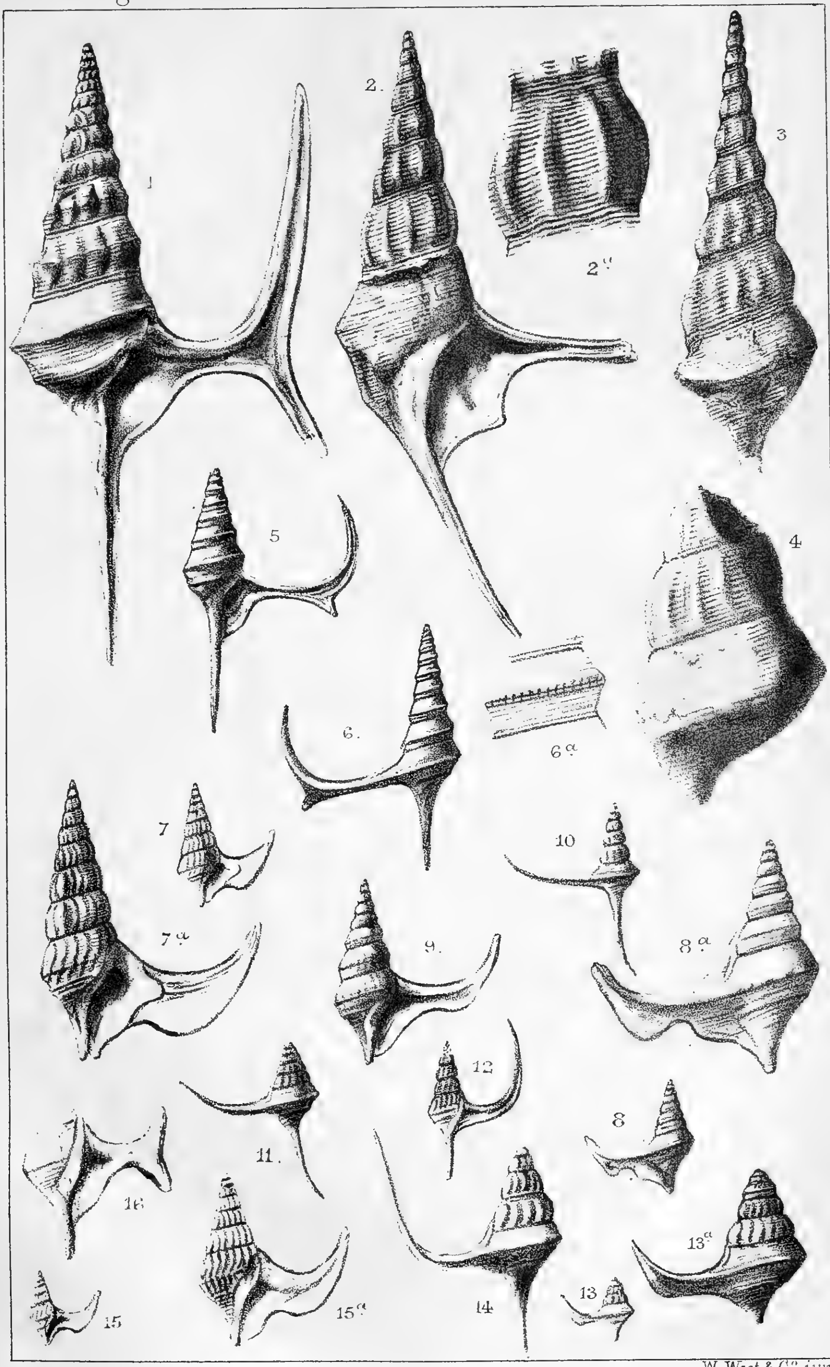
A. (*Pt.*) *Rochatiana,* D'Orb., has the form of *A. Fittoni,* but with unkeeled, inflated upper whorls, and tuberculated keels on the lower whorls. Neocomien.

A. angulosa, D'Orb., from Sta.-Fé de Bogota, is a small distinct species, with angular and pronounced keels. Neocomien.

A. Americana, D'Orb., *id.*, Colombia, St. Martin (Var), and Château-neuf (Hautes Alpes), has a slightly longer spire, angular whorls, keels as in *A. Mailleana,* and short expanded wing, linking the present group with Groups 3 and 4.

Fusus Cottaldinus, D'Orb., Ste.-Croix, is the young of *A. retusa.*

There is also a very distinct form in the splendid museum of the Ecole des Mines in Paris, which has a globular shape, with depressed spire ; all but the last whorls strongly striated and reticulated. The *Strombus pyriformis,* Kner, figured by Geinitz in the Quadersandsteingebirge, is probably intended to represent this species, as it is from the same locality—Lemberg.



G. F. De Wilde del. et lith. W. West & Co. imp.

Fossil Aporrhaïdæ.

The specimen labelled *A. retusa*, from Devizes, in the Jermyn Street Museum, has an expanded wing, and is more elongated anteriorly than *A. retusa* from Folkestone.

Addendum to Group 2.

There are two specimens from the Upper Greensand of Evershot of a large *Aporrhaïs*, allied to *A. cingulata*, in the collection of the Geological Museum, Jermyn Street. I shall take a future opportunity of describing them. Meanwhile, as they are perfectly distinct from any other Continental or British form, I propose to name them *Aporrhaïs Etheridgii*, in compliment to Mr. Etheridge, F.R.S., Palæontologist to the Geological Survey of Great Britain.

Erratum in last Number: p. 53, line 13, read, *except* from Aachen.

Group 3.—Spire long, whorls angulated, carinated or bicarinated, spirally striated, generally with nodes or ribs transverse to the whorls; wing narrow and long, simple or bifurcated. No posterior canal.

Type:—Aporrhaïs carinata, Mantell (1822). Plate V. Fig. 1.

Description.—Spire elongated, composed of about 12 convex angulated whorls, forming an angle of 21°; finely striated spirally, ornamented transversely on the convexity of the whorls by 10 or 11 salient, slightly oblique and generally elongated tubercles. The sutures are very visible and slightly keeled. Fainter and less regular striæ cross the spiral lines, and coincide in direction with the ribs; they are especially visible on the sutural keels. The tubercles entirely disappear on the last whorl, and are replaced by two very salient angular striated keels, the posterior of which is most prominent and is prolonged to the extremity of the wing, in the form of a very strong, narrow, rounded ridge; this ridge or wing process runs at first at right angles to the axis, and then abruptly curves upward and continues more or less parallel to the spire, which it equals or even exceeds in length; it terminates in a sharp point or canaliculated spine. A second anterior keel rises in most specimens, if not all, near the margin of the lip, runs parallel to the first for a short distance, and at the point of curvature, diverges in an opposite and slightly outward direction in the form of a comparatively short and sharp, solid spur; the space between the two keels forms a narrow triangular wing, truncated at its extremity. The wing is applied to the last, and sometimes very slightly to the penultimate whorl; although slender looking and elegant, it is remarkably thick and strong. The spire measures ·046, canal ·036; breadth, including wing, ·036; the length of posterior digit from the point of curvature is ·034, and of the anterior digit ·012. The outer lip between the wing and anterior canal is slightly sinuous; the anterior canal equals the length of the spire, is slender, and is either straight or curved to the right. Mouth narrow, columellar lip encrusted immediately round the aperture. A slight modification of this species occurs in the Upper Gault, in which the posterior digit of the wing is shorter, straighter, and diverges outwards; the anterior spur is longer in proportion to the wing, and the tubercles seem less elongated. They occur usually in a crushed condition.

Distribution.—This and *A. marginata,* Sow., are the most abundant Gasteropods at Folkestone, ranging through all the beds of the Gault, and being frequently found in masses together. Mantell, Fitton, and others mention it from Ringmer, Ridge, Bletchingley, Laughton, Norlington, Warminster (?), Cambridge, etc.

On the Continent its distribution seems restricted to the Paris basin, but many of the casts figured under other names may, on examination, be found to belong to this species, and its known localities would be thus extended. The spire without the last whorl or wing process may easily be confounded with *A. marginata,* and in the form of casts they are still more difficult to separate. It is eminently characteristic of the Gault.

History.—This shell was first figured and described by Mantell as *Rostellaria carinata,* in the Geology of Sussex, in 1822, p. 86, tab. xix., figs. 12 to 14; again by Sowerby in Fitton, 1836; and by D'Orbigny in 1842, who first published a tolerably perfect representation of the species. It was next noticed in D'Orbigny's Prodrome. Pictet and Campiche did not figure this form, but it is mentioned on page 624 in their list. In 1859 Dr. Chenu figured it, page 259 in the Manuel de Conch., as *Pteroceras carinata.* Mr. R. Tate in 1865 described it in the Geol. Repertory, p. 97, fig. 17, as an *Alaria.* It is the *Gladius carinatus* of Gabb, 1861.

Considering its abundance, it is surprising that it should have been noticed by so few authors, but it probably is owing to the resemblance of its spire and ornamentation to that of *A. marginata.* The following may be identical with *A. carinata* or are closely allied :—*R. Pictetiana,* de Loriol, 1861, Neocomien; *R. elegans, id.*; *R. Neckeriana,* Pict. and Roux, Perte-du-Rhône, figured from casts. *Pt. tuberosa,* Briart and Cornet, though greatly resembling *A. carinata,* is probably distinct.

Aporrhaïs elongata, J. Sowerby. Plate V. Figs. 2, 2*a*, 3.

Description.—Shell very elongated, spire forming an angle of 20°, and consisting of nine or ten convex whorls, which are one and a half times wider than high, finely striated spirally, and with ten or eleven salient, rounded ribs, which extend across the entire breadth of the whorls. Three or four of the striæ are much more defined near the apical suture, and form a narrow, distinct, flat region between the convex parts of the whorls, thus giving a decided character to the shell; the ribs nearly disappear on the last whorl, which has a single indistinct keel. The wing is a long straight projection at right angles to the axis; longer and narrower than that of *A. carinata,* which its termination should resemble. I have seen no specimen more perfect than the one I have figured, Plate V. Fig. 2; but John Griffiths, of Folkestone, remembers finding one with a wing terminating "like a pickaxe." This specimen, he thinks, found its way into Mr. Wiltshire's cabinet. The outer lip is angular; the columellar lip encrusted with the aperture, resembling *A. carinata.* The anterior canal is long, and curved slightly to the right. The length of the spire is ·054 and the canal ·038.

Distribution.—Gault of Folkestone, where it is rare; Cambridge (?).

History.—In 1836 Sowerby figured an undoubted fragment of this shell in Fitton's Memoir, Trans. Geol. Soc., pl. xi. fig. 16, p. 336, with the following note:—"Presumed to be a *Rostellaria* from its resemblance to *R. marginata;* from which it differs in its great length and smaller ribs." It has, however, a stronger resemblance still to *A. carinata,* to which it is most closely allied. D'Orbigny in the Prodrome, Pictet and Campiche, and Gabb mention it from Folkestone only, on Sowerby's authority.

This shell should continue to rank as a species, for although each differing character is not in itself of great importance, yet combined, they give a very distinct aspect to the shell.

APORRHAÏS MAXIMA,[1] Price (*A. marginata,* Pict. and Camp.). Plate V. Fig. 4.

Description.—Spire elongated, composed of eight or more convex whorls, forming a regular angle of about 30°, finely striated spirally, and ornamented transversely by about twelve regular ribs to each whorl, which extend from suture to suture. These ribs disappear on the last whorl, and are replaced by a single prominent and angular keel. The wing and anterior canal resemble those of *A. carinata.*

Distribution.—Gault of Folkestone, upper and lower beds. Gault of the Perte-du-Rhône and Ste.-Croix.

History.—An impression of a shell of this species was found at Folkestone by Mr. F. G. H. Price, who named it *Rostellaria maxima,* and described it in the GEOLOGICAL MAGAZINE for March, 1873. Owing to the crushed condition of the only specimen then known, and which I at the time carefully examined, it was not till a second specimen was found that I observed it to be identical with *A. marginata,* Pict. and Campiche, whose figure 2, pl. xciv., almost exactly resembles the fragment I have here figured. Pictet and Roux's figures present the same characters, but are of much smaller size. It is very desirable to obtain more perfect specimens.

APORRHAÏS CARINELLA, D'Orb. Plate V. Figs. 5, 6, 6*a*.

Description.—Shell elongated, the spire forming an angle of 21°, composed, when perfect, of twelve angulated whorls with a strongly developed, acutely angular keel, situated a little anterior to the middle of each whorl; a second anterior keel is nearly concealed by the suture, but appears on the last whorl. The whorls are finely striated, especially the region anterior to the keel. The ridges, which are very salient, are finely tuberculated at their apices, except on the last two whorls. On the last or body-whorl, the keel is still more prominent and acute, and is prolonged into a straight, angular, ridged or carinated process, at nearly right angles to the axis of the shell for a distance almost equalling the length of the spire, where it bifurcates; the anterior digit being a very short spur, and the posterior, a long, gradually recurved point. The aperture is narrow,

[1] Sowerby having employed the name *marginata* for a different species,—that now known as *Orbignyana,*—Mr. Price's name may stand.

and the outer lip sinuous: the anterior canal very long, slender and tapering; the columellar lip is incrusted. The length of the spire is ·023, and the canal ·017; the breadth, including wing, ·024.

Distribution.—It is rare at Folkestone, and is not recorded elsewhere in England. It is found in France and Switzerland—in the Paris basin, at Ervy, Dienville (specimens in the Sorbonne Museum), Girandot, Ste.-Croix, etc.

History.—This species was described by Sowerby in 1832 as a *Fusus,* and named by him *carinella,* in the Trans. Geol. Soc. 2nd series, vol. iii. p. 418, pl. 39, f. 24, and quoted by Michelin, Mém. Soc. Géol. vol. iii. p. 100, 1838, without description, as a *Rostellaria.* In 1842 D'Orbigny, in the Pal. Franc. Terr. Crét., vol. ii. p. 287, pl. 207, figs. 7 and 8, gave an excellent figure of this form. It seems to have had a wide range, being mentioned in the Prodrome, and by Cornuel in 1851 from the Haute-Marne, by Cotteau, 1854, and Raulin and Leymerie, 1858, from the Yonne. In 1864 it was figured by Pictet and Campiche, pl. 94, figs. 4—7, p. 616; the only difference between their figures and the present arises from the imperfection of the specimens they had to describe, as the striæ and tuberculated carinæ are only seen on very well perserved examples. In 1865, Mr. R. Tate mentioned it as a British species, and in 1869 it is found in Jaccard's list from the Middle Gault of Ste.-Croix.

Aporrhaïs calcarata, J. Sowerby. Plate V. Figs. 7–14*a*.

Description.—Shell moderately elongated, conical; spire forming an angle averaging about 32°, diminishing rapidly towards the apex, which forms an obtuse termination; it is composed of six convex whorls. The whorls are finely but very distinctly striated spirally, ornamented transversely by many oblique, flexuous and equal ribs. Commencing from the apex, the first three whorls have a prominent angular, median keel, the transverse ribs not becoming visible till the third whorl; on the fourth and fifth the keel is hidden by the succeeding whorls, to reappear on the last. On these (the fourth and fifth whorls) the ribs are also very pronounced, and are still quite visible on the posterior region of the last. The last whorl has therefore a salient, angular keel at about its centre, and a less salient keel anterior to it; the region posterior to the dominant keel is ornamented by transverse ribs, similar to those on the other whorls, and, as stated above, the keel is continued up the spire, but is hidden by the suture; the remainder of the whorl is finely but distinctly and regularly striated. The dominant keel is prolonged in a strong, striated, and acute narrow and simple digitation, at first at right angles to the axis, and then curving gradually upwards, it exceeds the spire in length, and terminates in a sharp point. In many specimens, however, it is shorter, and perhaps a little broader. The aperture is narrow, and is encrusted on the columellar side; the anterior canal is long and straight; the outer lip is toothed; and the wing applied to the last whorl only. The average length of the shell is about ·006; they are found at Blackdown as long as ·020.

In a specimen from an upper bed of the Gault at Folkestone, Fig. 10, there are more whorls, the keels near the apex are less visible, and there are no ribs on the last two whorls; the canal is very long, considerably exceeding the length of the spire.

The Blackdown specimens present a somewhat different aspect, and the description of this species, to apply to them, has to be modified in the following manner:—there are seven to eight or nine whorls, the spire varies from an angle of about 22° to 33°, and is sometimes pupæform, but with the apex drawn out and tapering very gradually. The last two or three whorls form an obtuse termination in *exactly the same manner as the Folkestone shell*, but this termination is far less conspicuous, and only to be seen in well preserved specimens, or by the aid of a lens, as the spire tapers to a finer point, and the apical whorls are therefore smaller. The mode of growth is the same as that of the Folkestone forms, *but nothing could be more variable than the number and distinctness of the ribs.* These are sometimes entirely obliterated, leaving only faint traces in crossing the keels (Fig. 8),[1] sometimes they are very pronounced and regular (Fig. 1). On the last whorl in particular, the ribs are sometimes wholly absent, in other cases they extend to the anterior keel, being bent in their passage over the median keel, giving them an angularly flexuous appearance (Fig. 15). There are strongly marked varices on some of the shells. The wing is shorter, broader and stronger, but when perfect is always produced in an acute, upward point: at the point of curvature it is broad, with even, though very rarely, a tendency to become bifurcated (see Fig. 16). The aperture is the same as in the Folkestone shells, but the anterior canal is never long.

These differences would be by many, as they have been by Prof. Morris and others, considered sufficient to constitute the Blackdown fossils into a separate species; but frequent examination of a large series of specimens has convinced me that they cannot be so separated, as I am utterly unable to find any fixed specific character by which to distinguish them; the more ordinary forms of this shell from both localities being all but identical with each other. I shall allude farther on again to these differences, and hope to offer some explanations which may help to account for them.

Distribution.—It is exceedingly abundant both at Folkestone and Blackdown, and not uncommon at Shanklin. On the Continent it is found at Ervy, Courtaout, Dienville, Cosne, etc., and specimens may be seen in most museums.

History.—Parkinson first figured this species as a *Rostellarite* in the Organic Remains, vol. iii. p. 63, pl. v. fig. 2. Sowerby in the Min. Conch. vol. iv. p. 69, pl. 349, figured and described it very carefully, naming it *R. calcarata*; and D'Orbigny in 1842 gave an enlarged figure of this shell from the Gault of Ervy, Pal. Fr. Terr. Crét. pl. 207, fig. 3.

I am not quite certain whether the figures and descriptions of *A. Muleti*, *composita*, etc., of other authors are identical with our species, as their shells are considerably larger, specimens in the

[1] Mr. Ralph Tate, Geol. and Nat. Hist. Repertory, Sept. 1865, named this variety "*neglecta*."

Vienna and Dresden Museums being an inch long. Those from Blackdown seem occasionally to have attained a greater size, but never approaching the size of the European forms just mentioned. It is the smallest *Aporrhaïs* of the group.

The following allied forms are figured in various works, but their identity with *A. calcarata* of Sowerby is uncertain, and they seem to be intermediate between this form and *A. carinata.*

R. stenoptera, Goldf. Greensand, Aachen.

R. Buchii, Münst., Geinitz.

? *R. calcarata* (Sby.), Geinitz, Reuss. Zekeli.

R. composita, Leymerie.

A. Muleti, D'Orb., Pictet and Campiche.

J. Müller, in the Monogr. der Petrefacten des Aachen Kreideformation, figures a remarkable assemblage of Aporrhaïdes that are near to *A. calcarata,* but some with monstrous forms of wing, see especially *Str. arachnoides,* figured by Geinitz in his Quadersandsteingebirge, tab. ix. f. 5. They are:—*R. minuta, R. arachnoides, R. granulosa, R. furca, R. Nilssoni.*

EXPLANATION OF PLATE V.

Fig. 1.—*Aporrhaïs carinata*, Folkestone. Full grown. From the author's cabinet. N.B.—The spiral angle is apparently increased, owing to the specimen being slightly flattened.
Fig. 2.—*A. elongata*, Folkestone.
Fig. 2*a*.—Portion magnified. Both from the author's cabinet.
Fig. 3.—Spire of *A. elongata.* From Mr. Price's collection.
Fig. 4.—*A. maxima*, Folkestone. From a fragment in Mr. Price's collection.
Fig. 5.—*A. carinella*, Folkestone. Ventral side of a full-grown specimen.
Fig. 6.—*A. carinella.* Dorsal view of another specimen.
Fig. 6*a*.—A portion magnified. Both from the author's cabinet.
Fig. 7.—*A. calcarata*, specimen from Blackdown, showing varices. In the Brit. Mus.
Fig. 7*a*.—Portion enlarged.
Fig. 8.—Specimen with faintly marked ribs. In the British Museum.
Fig. 8*a*.—Same, enlarged.
Fig. 9.—A pupæform specimen. In the British Museum.
Fig. 10.—Specimen from Folkestone, from an Upper Bed of the Gault. In the author's cabinet.
Figs. 11, 12, 13.—Specimens from the usual Lower Bed, Folkestone. From the same.
Fig. 13*a*.—Same, enlarged.
Fig. 14.—A specimen from the same, enlarged twice. In the British Museum.
Fig. 15.—Specimen from Blackdown strongly ribbed. In the British Museum.
Fig. 15*a*.—Same, enlarged.
Fig. 16.—Specimen with bifurcated wing from Blackdown. In the Brit. Museum.

(To be continued in our next Number.)

REVIEWS.

I.—Economic Geology; or, Geology in its relations to the Arts and Manufactures. By David Page, LL.D. 8vo. pp. 336. (Edinburgh and London: Blackwood and Sons, 1874.)

It has been said that the ultimate aim of geological inquiry is to restore in imagination the physical geography of by-gone periods; to restore, however dimly, the former extent in different times of land

and water; and to picture the forms of animal and vegetable life that have from time to time existed. But there is another, and perhaps to the majority of mankind, a higher aim in Geology, one that also leads to noble thoughts and lofty aspirations—sometimes also *to the realization of large fortunes*—the study of Economic Geology.

The application of Geology to the Arts and Manufactures has been brought prominently before us by Professor Ansted in several published works. They have been illustrated in the Museum of Practical Geology, and special branches of the subject have been treated of in works by Prestwich, Hull, Smyth, and many others, as well as in the Reports of some of our Royal Commissions. The connexion between Geology and other sciences is as much displayed in its economic bearings as in its purely natural history relations.

Dr. Page has produced a very comprehensive work. The relations between Geology, Agriculture, and Land Valuation are discussed, likewise those in connexion with Architecture, Civil and Mine Engineering. One chapter is devoted to Heat and Light producing materials; and another to Geology and the Fictile Arts, treating of the Clays we fabricate, the Sands we vitrify, and Glazes, Enamels, and Colours. Chapters are devoted to Grinding, Whetting, and Polishing Materials; to Refractory or Fire-resisting substances; to Pigments, Dyes, and Detergents; to Salts and Saline Earths; to Mineral and Thermal Springs; to Mineral Medicines; to Gems and Precious Stones; and, lastly, to the Metals and Metallic Ores.

At the end of each chapter Dr. Page has enumerated some of the most important works that may be consulted when details on particular subjects are required. In a work of so comprehensive a kind as this, it is impossible not to find some subjects which appear to be rather scantily treated. We might have expected some particular notice of Irish peat, or a reference to the localities in England where it has been dug. The ages and modes of occurrence of the clays we fabricate are hardly noticed at all. But we must not forget the cosmopolitan nature of the work, and that the addition of much more material would have rendered it too bulky for a Text-book. We may congratulate Dr. Page in having produced this book, which cannot fail to be very largely and widely appreciated.

II.—Valleys and their Relation to Fissures, Fractures, and Faults. By G. H. Kinahan. 8vo. pp. 240. (London: Trübner & Co., 1875.)

THOSE who have been spectators of the course of Geological Theory during the past ten or fifteen years must have been struck by the many, seemingly one-sided, explanations that have been given to account for the origin of the present land configuration. The early teachings of Hutton, and of Scrope, have perhaps been more fully appreciated in late years than they were fifty years ago.

The effects of rain and river action have been more fully explained, and the great influence of glacial action in comparatively recent times has been also taken into account. Nor has the agency of the sea been neglected, although it has been clearly proved that meteoric agencies combined, by reason of the greater surface they have to act upon, far exceed in destructive power the influence of oceanic waves and currents. It may be fairly questioned, however, whether some observers have given due credit to all denuding agencies, in their explanations of the origin of scenery; or whether they have adequately appreciated the effects of forces apart from those of denudation. If we cannot follow the Duke of Argyll in all his interpretations of geological phenomena, we can yet be thankful for the words of caution he has given in his eloquent writings. There is no doubt that ice, rain, rivers, and sea have performed the denudation. The question is, how far have other agencies directed their action?

In the work before us Mr. Kinahan has endeavoured to demonstrate that, in general, valleys are connected with faults or breaks, and that a valley or hollow could seldom have been carved out unless there were cracks, minor joints, or other shrinkage fissures, in which one or other of the different denudants could work. He very fairly acknowledges that meteoric abrasion (or sub-aerial denudation) seems to be the most universal performer in the great work of denudation, but that without the aid of faults and joints, few valleys could have acquired their present form. The fact that internal forces of disturbance may have ceased to act long before present surfaces were formed, does not affect the question of their influence. The author points out the relations existing between breaks, faults, and lake-basins, particularly in Ireland; nevertheless, ice-action and meteoric abrasion have been the denudants, while the situation and shape have been influenced by the earlier forces.

Although objections may be taken to some of Mr. Kinahan's conclusions, yet on the whole his book is a valuable addition to the literature of Physical Geology. The majority of the facts stated are from the observations of himself and his colleague the late Mr. Warren on the Geological Survey in Ireland, and it is such experience gained by detailed investigations that must always form the basis of our theories, especially when taken in conjunction with the facts observed in different parts of the world.

REPORTS AND PROCEEDINGS.

Geological Society of London.—I.—December 16, 1874.—John Evans, Esq., F.R.S., President, in the Chair.—The following communications were read:—

1. "Descriptions of the Graptolites of the Arenig and Llandeilo Rocks of St. David's." By John Hopkinson, Esq., F.G.S., and Charles Lapworth, Esq., F.G.S.

Commencing with a brief historical account of the discovery of Graptolites in the neighbourhood of St. David's, from their first discovery in the Llandeilo series in 1841 by Sir Henry de la Beche and Professor Ramsay, the authors proceeded to explain their views on the classification of the Graptolites (Graptolithina, Bronn), which they place under the order *Hydroida*, dividing them into two groups, Rhabdophora (Allman), comprising the true siculate or virgulate Graptolites, which they consider to have been free organisms, and Cladophora (Hopkinson), comprising the dendroid

Graptolites and their allies, which were almost certainly fixed, and are most nearly allied to the recent *Thecaphora*.

The distribution of the genera and species in the Arenig and Llandeilo rocks of St. David's was then treated of, and the different assemblages of species in each of their subdivisions were compared with those of other areas.

The Arenig rocks are seen to contain a number of species which ally them more closely to the Quebec group of Canada than to any other series of rocks, all their subdivisions containing Quebec species, while the Skiddaw Slates, which before the discovery of Graptolites in the Lower Arenig rocks of Ramsey Island in 1872 were considered to be our oldest Graptolite-bearing rocks, can only be correlated with the Middle and Upper Arenigs of St. David's. The Graptolites of the Arenig rocks of Shropshire and of more distant localities were also compared with those of St. David's.

In the Llandeilo series of this district the *Cladophora* have now for the first time been found, a few species, with several species of *Rhabdophora*, occurring at Abereiddy Bay in the Lower Llandeilo, which alone has been carefully worked, there being much more to be done in the Middle and Upper Llandeilo, from which very few species of Graptolites have as yet been obtained.

Some of the recently introduced terms, and altered or more definite terminology, employed in the descriptions of the species were then explained; and the paper concluded with descriptions of all the species of Graptolites collected in the Arenig and Llandeilo rocks of St. David's within the last few years of which sufficiently perfect specimens have been obtained, doubtful species being referred to in an appendix.

Forty-two species were described belonging to the following genera:—*Didymograptus, Tetragraptus, Clemagraptus* (gen. nov.), *Dicellograptus, Climacograptus, Diplograptus, Phyllograptus, Glossograptus,* and *Trigonograptus* (Rhabdophora); *Ptilograptus, Dendrograptus, Callograptus,* and *Dictyograptus* (Cladophora).

Discussion.—Mr. Carruthers said that this paper greatly added to our knowledge of the Graptolites. He had doubts as to the true position of the Cladophora. Of the Rhabdophora the later forms seemed to be simpler in their structure than the earlier ones.

Mr. Hicks stated that the branching forms occur in the lowest part of Ramsey island, together with the dendroid forms.

Prof. T. Rupert Jones inquired whether, if it were true that the later forms of Graptolites were simpler than the older ones, we may regard this as due to a degeneration leading towards an extinction of the type.

Mr. Hopkinson, in reply, stated that the dendroid forms are only known to occur in abundance in Britain in the Arenig rocks of St. David's; and that there are here intermediate forms connecting the British and American species which occur in rocks of more ancient age. He remarked that he did not consider the dendroid forms valuable for determining zones, species very nearly allied to those of the Arenig rocks being met with even in the Lower Ludlow rocks of Shropshire; but the Rhabdophora occur only in small zones, and wherever they are found, they seem to hold an equivalent position. They are consequently valuable for stratigraphical purposes. Mr. Hopkinson stated that in recent deep sea dredgings Hydroids had been found approaching the Graptolites in structure, and that Graptolites have also lately been discovered which have many points in common with the recent sertularian Zoophytes.

2. "On the Age and Correlations of the Plant-bearing series of India, and the former existence of an Indo-Oceanic Continent." By H. F. Blanford, Esq., F.G.S.

In this paper the author showed that the plant-bearing series of India ranges from early Permian to the latest Jurassic times, indicating that, with few and local exceptions, land and freshwater conditions had prevailed uninterruptedly over its area during this long lapse of time, and perhaps even from an earlier period. In the early Permian there is evidence in the shape of boulder-beds and breccias underlying the lowest beds of the Talchir group of a prevalence of cold climate down to low latitudes in India, and, as the observations of geologists in South Africa and Australia would seem to show, in both hemispheres simultaneously. With the decrease of cold the author believed the Flora and Reptilian Fauna of Permian times were diffused to Africa, India, and perhaps Australia; or the Flora may have existed somewhat earlier in Australia, and have been diffused thence. The evidence he thought showed that during the Permian epoch India, South Africa, and Australia, were connected by an Indo-oceanic continent, and that the first two remained so connected, with at the utmost some short intervals, up to the end of the Miocene period. During the latter part of the time this continent was also connected with Malayana. The position of the connecting land was said to be indicated by the range of coral reefs and banks that now exist between the Arabian Sea and West Africa. Up to the end of the Nummulitic epoch, except perhaps for short periods, no direct connexion existed between India and Western Asia.

Discussion.—Prof. Ramsay said that he thought the age of the different beds referred to had been correctly determined by the author. He doubted whether there was any great difference between the Permian and the Triassic deposits. He referred to the time when the possibility of the occurrence of glaciation in Permian times was doubted, but erratic boulder-beds of undoubtedly Permian age had since been described as occurring in South Africa, and he thought there was a general tendency to admit the possibility of Permian glaciation. He remarked that, according to Mr. Croll, glacial periods occur at intervals, alternating on the northern and southern hemispheres every 25,000 years. The south is now under more glacial conditions than the north, and during the formation of our Boulder-clay the southern hemisphere had a more temperate climate. Prof. Ramsay agreed with the author in the belief of the junction of Africa with India and Australia in geological times.

Prof. T. Rupert Jones said that he wished to express his high appreciation of the masterly summary of the facts and theories relating to the wide extension of the early Mesozoic fauna and flora given by Mr. Blanford in this paper, and supplemented by the results of his own personal observations on the Geology of India. He referred to the still stronger evidence which the Karoo beds would probably afford when their reptiles shall have been all worked out. Their Palæoniscan fishes would form no exception to their Mesozoic character, as *Palæoniscus* occurs in the English Trias. The conglomerate bed at the base of the Karoo, though described as glacial in Natal, presents peculiarly volcanic characters in other parts of South Africa. Referring to the occurrence of a Labyrinthodont in Australia, Prof. Jones dated the rise of the inquiry into the extent of Mesozoic land in the Southern hemisphere from Prof. Huxley's notice of this and other Amphibians and his own observations on the range of *Estheriæ*. He thought that the Mesozoic plant-bearing and reptiliferous beds of Carolina and Virginia had very similar relations to those mentioned in the paper. In conclusion he referred to the more recent glaciation of South Africa described by Mr. Stow, and also to Mr. Belt's popular exposition of the hypothesis of bipolar glaciation, and suggested that the earth's passing through cold stellar spaces might perhaps be the real cause of glacial epochs.

Mr. Drew wished to know what were Mr. Blanford's views as to the land from which the river came that deposited the strata with which the plant-remains were associated. With such great thicknesses as 11,000 and 15,000 feet of fluviatile beds, the occurrence of which implied a corresponding amount of sinking, there must, he thought, at one time have been very high land, which was thus drained and denuded. He inquired what portion, if any, of this land now remains.

Mr. Carruthers said he thought that in South Africa there are four distinct plant-beds, and that the base-bed is higher than the Permian, belonging to the Jurassic series, and probably to the Oolite.

Mr. Woodward was pleased to find that the author had added further evidence, derived from the fossil flora of the Mesozoic series of India, in corroboration of the views of Huxley, Sclater, and others as to the former existence of an old submerged continent ("Lemuria"), which Darwin's researches on coral reefs had long since foreshadowed. Mr. Blanford's observations on the former existence of glaciers at much lower levels than the present snow-line of India added another valuable piece of evidence to those collected by Mr. T. Belt in Nicaragua and elsewhere. But any theory pretending to account satisfactorily for the glacial epoch must not only explain the lower level of former glaciers in the tropics, but the former existence of a warm, temperate, and even subtropical fauna and flora in high northern latitudes, as shown by Heer, McClintock, and others, not to be provided for by Croll's theory or that of Balfour Stewart, but by periodic variation in the inclination of the earth's axis, as suggested by Belt, and long since by the Rev. Prof. Haughton in the Society's Journal.

Mr. Bauerman considered that the author's conclusions were, in the main, borne out by the evidence afforded by those portions of the Indian coal-fields with which he was acquainted. He thought, however, that there was a difficulty in the precise correlation of the Coal-bearing series of Western India with those of Bengal, owing to the absence of the best physical horizon in the Ironstone series in the western district. From what he had seen of the Talchir section in the Nerbudda valley, he was not inclined to agree with the author as to their glacial origin; but he was not acquainted with the other section referred to in the Godavery valley. He considered that the author's conclusion as to the age of the volcanic series of the Deccan was confirmed by the evidence of rocks of similar character occurring in Eastern Africa on the south side of the Gulf of Aden.

Dr. Murie thought the evidence derived from the living forms of animals was in favour of their migration to or from Africa through Arabia, but not by way of the Maldive group.

The author, in reply, remarked that the ancient continent would not furnish glaciers unless it was of very great height. He suggested that the boulders referred to might have been due to the action of winter ice.

II.—January 13, 1875.—John Evans, Esq., F.R.S., President, in the Chair. The following communications were read:—

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

The author described in considerable detail the development of the Kimmeridge Clay in various parts of England, dwelling especially upon the palæontological phenomena presented by it in the different localities. He arrived at the conclusion that the Kimmeridge Clay in England is divisible only into two sections, Upper and Lower; but when it is preceded by the Coral Rag, it possesses a basal series of no great thickness, which may be designated the Kimmeridge Passage-beds. He compared his Upper Kimmeridge with the lower part of the "Virgulien" with foreign authors. It consists of paper shales, paper slabs, bituminous shales, and cement stones, with interstratified clays, and may attain a thickness of at least 650 feet. Its fauna is characterized by paucity of species and great abundance of individuals. It is thickest in Dorsetshire and Lincolnshire, but thin or absent in the inland counties. The author stated that no Fauna comparable with that of the Middle Kimmeridge or "Ptérocerien" has been discovered in England, though some of its less characteristic fossils occur associated with Lower-Kimmeridge forms. The Lower Kimmeridge is a mass of blue or sandy clay, with numerous calcareous "doggers," largely developed in Lincolnshire, the whole representing the "Astartien" of foreign geologists. Its thickness is estimated at from 300 to 500 feet in Ringstead Bay, and about 400 feet in Lincolnshire. The fossils of the Coral Rag extend up into the Kimmeridge passage-beds, which are typically developed at Weymouth, where they are about 20 feet thick.

Discussion.—Prof. Seeley complimented the author on the elaborate palæontological details which he had correlated in his paper. He noticed that the Kimmeridge Clay is thinnest in the neighbourhood of Ely, and thickens to the north, in Lincolnshire, and also southward, and that this southward thickening is concomitant with a development of sandy beds at the base and less markedly also at the top. As the formation is traced into France by way of Boulogne, the sandy characters become more strongly marked, and eventually the deposit can no longer be recognized as a Clay, though westward, at Havre, it is as much a clay as at Weymouth. He then called attention to the fact that in France there is a large curve of igneous rocks, roughly parallel to the present outcrop of the English Secondary strata, partly broken through by a mass of Palæozoic rocks, extending northward from Strasburg through Belgium, and by way of Harwich towards the Cambridgeshire area. He thought that the denudation of these deposits probably furnished the materials of the southern portion of the beds under consideration; and if so, the stratigraphical sequence becomes intelligible in this way,—the Kimmeridge Grit, being sandy, resulted from an elevation of this igneous curve, and the mass of the Kimmeridge indicated that the curve was depressed so that the sand did not reach the British area, while the covering sand shows that it was again upheaved. The bottom sand is in physical continuity with the upper Calcareous Grit, and the upper sand is similarly continuous with the Portland Sand, so that he doubted whether any portion of the series is really wanting in England.

2. "Note on *Pelobatochelys Blakei* and other Vetebrate Fossils obtained by the Rev. J. F. Blake from the Kimmeridge Clay." By Harry Govier Seeley, Esq., F.L.S., F.G.S., Professor of Physical Geography in the Bedford College, London.

The author stated the fossils referred to in his paper gave evidence of three species of *Ichthyosaurus* (one larger than any previously known to occur in the formation), a *Pliosaurus*, a *Steneosaurus*, a small Ornithosaurian, and a species of Chelonian, which he described under the name of *Pelobatochelys Blakei*. The remains of this animal indicated a carapace sixteen inches long by fourteen inches broad, and angularly arched posteriorly. The pygal scute was divided as in *Emys*, and the hinder margins of the vertebral scutes were elevated as in some species of *Batagur*. The vertical scutes were nearly twice as broad as long, and interlaced with each other by sawlike margins. The costal plates were imperfectly ossified.

3. "On the Cambridge Gault and Greensand." By A. J. Jukes-Browne, Esq., F.G.S.

This paper has for its object to determine the true position of the Cambridge nodule-bed in the Cretaceous series, and to investigate the nature and origin of its peculiar fauna.

The first part of the paper deals with the stratigraphical relations of the beds; and the author calls attention to the fact that in the numerous artificial sections near Cambridge only two formations are really visible, viz. the Chalk Marl with a pebble-bed of phosphatic nodules at the base, and the stiff dark clay of the Gault, upon which these rest.

The so-called Greensand or nodule-bed passes up into the Chalk Marl, but rests unconformably on the Gault below, which presents in fact a *surface of erosion*; and there is therefore a *break of indefinite length* between the Cambridge Gault and Greensand.

The nodule-bed continues to present much the same characters and fossils through Bedfordshire as far as Sharpenhoe, a village about three miles east of Harlington, on the Midland Railway. Here is situated the most westerly coprolite pit or working in the Cambridge bed; and beyond this the Gault passes into Chalk Marl without any such seam intervening.

It is not until we enter Buckinghamshire and reach Buckland near Tring, that anything like true Upper Greensand appears, and separates the Chalk Marl from the Gault. From this point westward the formation increases in thickness and importance, but its characters and fossils are quite different from those of the Cambridge Greensand.

Although in Bucks no coprolites are found between the Gault and Greensand, yet they occur in the Gault itself; and one bed may be traced towards the N.E., and is found to commence where the Cambridge nodule-bed ends, thereby raising the presumption that it becomes confluent with that bed, and has furnished many of the well-known fossils and nodules it contains.

A consideration of these facts warrants the following general conclusions:—

1. That the Cambridge Greensand or nodule-bed has no connexion with the Upper Greensand, its actual position being at the base of the true Chalk Marl.

II. That the same bed rests unconformably on the clay below, and that its coprolites and fossils have been derived from the Gault.

III. That in consequence of this erosion a great gap now exists in Cambridgeshire between the Lower Gault and the Chalk Marl, the whole of the Upper Gault and Upper Greensand being absent.

The palæontological evidence leads to exactly the same conclusions. The fauna is divisible into two groups, and the fossils belonging to the one are preserved in dark phosphate, and being generally water-worn are clearly derived forms, while the others are of lighter colour, and belong to the deposit. The former group is chiefly composed of Gault species, seventy per cent. of which belong to the upper stage of that formation; while the fossils proper to the deposit are also found in the Chalk Marl above.

The author therefore feels justified in concluding that stratigraphically the bed is Chalk Marl, while palæontologically considered its fauna is mainly derived from the Upper Gault.

Discussion.—Mr. Charlesworth considered that the vexed question of the true relations of the so-called Upper Greensand of Cambridge had been now determined, and that it must be regarded as Gault. The presence of *Endogenites erosa* and other Wealden forms in the deposit at Potton in Bedfordshire, would seem to show that it belonged to the Wealden; while the presence of Kimmeridge species might be taken to prove that it was Kimmeridge. With regard to the so-called coprolites, he remarked that it was difficult to assign those of the Red Crag, as well as those of Cambridge, to their true position. He inquired how did the phosphatic nodules originate? Some observers maintain that they are rolled, but in the Crag the sharks' teeth have nodules attached to their base, and these could not have been acted upon by erosion. He thought the phosphates were derived either from decomposed marine vegetation or from excrements.

Mr. Price remarked that he had examined 75 or 80 species of fossils from the Cambridge deposit in the Woodwardian Museum, and found that 33 per cent. of them pertained to the Upper Gault.

Prof. Seeley remarked that when he commenced the study of the question discussed in Mr. Jukes-Browne's paper, the fossils of the so-called Cambridge Upper Greensand were very imperfectly known, and the prevalent belief among palæontologists was that the stratum represented the Gault. As the collections at Cambridge were accumulated, and his acquaintance with English sections of similar deposits was enlarged, he had enjoyed opportunities of discussing the question with foreign palæontologists, and now believed that the deposit essentially represented the English Upper Greensand. He had noticed that the surface of the Gault on which the Greensand rests is eroded, the phosphatic nodules being spread uniformly, though the Vertebrate fossils were often contained in hollows of the surface of the Gault. Occasionally the phosphatic bed was covered by a discontinuous dark-coloured clayey bed, divided from the Chalk Marl by a sharp line of bedding. He thought that this band might result from denudation of Gault, and the fact that it did not interfere with the continuity of the bed of phosphatic nodules seemed to show that the denudation was local and of small extent. The fact that sand was superimposed upon clay, necessarily implied an upheaval of the sea-bottom, and therefore the newest-formed beds of the Gault were sure to be denuded to some extent in consequence. But while this circumstance would explain the occurrence of a small per-centage of Gault species, it rendered it rather improbable that so varied a fauna should have been derived from a denuded portion of one stratum. Mr. Seeley's own investigations had not led him to detect in the bed any preponderance of Gault forms. He further found that the remains of Vertebrates in the Cambridge Upper Greensand were associated series of bones, which would not be the case were they derived fossils, and that no species of reptile had yet been identified as common to the Cambridge Greensand and the Gault. He thought that the thinness of the Cambridge Greensand, as well as the complex nature of its fauna, was only to be understood by considering the circumstances of physical geography under which the deposit originated; and upon this some light was thrown by the thinness of the Kimmeridge Clay in the same area, and by the occurrence of phosphatic nodules in that area in the so-called Neocomian beds. These beds, like the Cambridge Greensand, contain fossils derived from the Carboniferous Limestone and fragments of Palæozoic rocks, so that the phosphates might have been furnished to the sea in which the deposit was formed by denudation of eruptive dykes of apatite, such as Mr. D. Forbes had informed him were to be met with traversing Palæozoic rocks in Spain, Norway, and other countries. Taking all these facts into consideration, he was inclined to hesitate for the present in accepting Mr. Jukes-Browne's hypothesis.

Mr. Forbes, with reference to Mr. Seeley's observations, stated that he had found true eruptive lodes or dykes of phosphate of lime (phosphorite or apatite) traversing the Silurian and Devonian strata and granites of Estremadura in Spain and Portugal, and often extending for miles; and also others breaking through the metamorphic schists of the south of Norway. Some years back he had explained the phosphorite in the deposits of Nassau as resulting from submarine eruptions, which brought it up and left it on the sea-bottom in the form of breccia and tuff, precisely as a volcanic rock would do under similar circumstances. So far as he had examined the phosphatic nodules of the Cambridge Greensand, however, he had not found that their mineral structure indicated any such eruptive origin.

The Rev. T. G. Bonney remarked that Mr. Seeley's observations bore upon a large question, affecting our whole system of geological nomenclature rather than the immediate subject. The nomenclature being as it was, he thought Mr.

Browne was fully justified in his conclusions. In the Cambridge deposit we have two distinct faunas; one, as shown by per-centages, related to the Chalk Marl, the other to the Upper Gault; two conditions of mineralization; evidence of erosion in the irregular junction of the two beds, in the waterworn condition of many of the nodules, in the fact that they had *Plicatulæ*, Polyzoa, etc. attached; the nodules also could be detected in the Gault, not only in the particular seam which had been described, but at intervals throughout the mass; also erratics of some size occurred in the phosphate bed. These facts, he thought, proved the existence of a break. He thought that associated bones were rarer than Mr. Seeley described them to be. It appeared to him that some of the speakers had forgotten that the question of the origin of the nodules had already been brought before the Society by Mr. Sollas and Mr. Fisher, who have shown very many of them to be phosphatized sponges.

Mr. Whitaker, from his experience in mapping the Geology of the Cambridge district, came to the conclusion that the bed is really the base of the Chalk Marl, there being a regular passage up into the latter. He questioned whether the Upper Greensand is a separate formation.

Mr. Hawkins Johnson said that the microscopical structure of the phosphatic nodules is identical with that of septaria from the London Clay, with that of the Clay-ironstone nodules of Yorkshire, and with that of some septaria from the Kimmeridge Clay. Moderately thin sections subjected to the action of dilute acid (even acetic acid), and examined while moist, show a structure like that of sponge.

The President remarked that the difference between Mr. Jukes-Browne and Mr. Seeley appeared to be on a question of fact. He remarked upon the difficulty of distinguishing between the Chalk and the Upper Greensand.

The Author, in reply, said that he was only concerned with the question of where the coprolites had come from, and not that of how they originated; he had not therefore touched upon the formation of phosphatic nodules. He thought Mr. Seeley had admitted some of the most important points of his paper, viz. the eroded surface of the Gault, the confluence of the Cambridge nodule-bed with that of the Gault, and the consequent derivation of many of its fossils. He must, however, maintain that there was a complete passage between the Greensand and the Marl above, and no trace of a second line of erosion, as Mr. Seeley appeared to think. With regard to the vertebrate remains, those preserved in dark phosphate were always worn and rolled, while the associated bones Mr. Seeley spoke of were light in colour, and undoubtedly belonged to the formation itself, *i.e.* to the base of the Chalk Marl. Lastly, the lists and per-centages contained in the paper would show whether or not there was a preponderance of Gault forms in the deposit, and the author was quite prepared to abide by observed facts and palæontological results.

CORRESPONDENCE.

ON THE CRETACEOUS *APORRHAÏDÆ*.

Sir,—In the February Number, your contributor, Mr. J. Starkie Gardner, writing on *Aporrhaïs retusa*, Sow., says, "I cannot find the type or any specimen from Blackdown, and there is a doubt whether the same species is intended." It is curious that he should apparently not have read page 239 of Fitton's memoir, where it is stated that his types belonged to the Bristol Institution, and are "now in the Museum of that establishment." (See also Proc. Bristol Naturalists' Soc., vii. pt. 2, p. 41.) In the Catalogue of Blackdown Fossils, pp. 239–242, Fitton is very careful to indicate against each species the collection in which the specimens may be found. Your contributor also writes, "Should the Blackdown form prove distinct, Deshayes's name of *bicarinata* must be adopted for it." We should claim priority for the Blackdown type; and in case of non-identity, it is the Gault form rather to which the French author's name may be apportioned. However, I have little doubt but that they are one and the same species. The single specimen, imperfect as to the digits, from which J. Sowerby drew up his description, seems to me to agree precisely with the Folkestone forms, except that the keels are a little less pronounced; but this is evidently due to the somewhat toned-down state of the specimen; there are seven to eight threads above the keel, and four between the keels, of which the two central are a little stronger than the remaining two. The surface, instead of being "particularly smooth," as Sowerby says, I should describe as showing traces of oblique cross lines, which have become very obscure through abrasion. I regret that I am unable to compare it with the foreign descriptions, but the Museum is quite without the necessary books.

Bristol Museum,
February 18*th*, 1875.

E. B. Tawney.

DEEP BORING IN PRUSSIA.

Sir,—The experimental boring at Sperenberg having revealed the existence of a deposit of rock-salt, greatly exceeding that of any previously known, I send you some further details, for which I am again indebted to Professor A. von Koenen, of Marburg.

The boring was begun in gypsum, probably belonging to the Muschelkalk. As the boring proceeded, the gypsum was found to become gradually mixed with Anhydrite, and then to pass into pure Anhydrite. Still lower, a little rock-salt was met with; and afterwards at 88·8 metres (291⅓ English feet) pure rock-salt, in which the boring continued down to 1271·63 metres (4171 English feet); no other rocks besides gypsum and salt having been met with.

Two other borings, at some distance from the first, have reached the rock-salt at 120·6 and 115·8 metres respectively, or at 395⅓ and 380 English feet.

Prof. von Koenen recommends English geologists, who take an interest in the subject of the increase of the Earth's temperature in proportion to depth, to consult the papers of Obergrath Dunker in that volume of the "Zeitschrift für das Berg- Hütten- und Salinen-Wisen in dem Preussischen Staate," which contains an account of the boring, viz. vol. xx. (1872).

The reduction of Prussian into English feet being incorrect in my former letter, I avail myself of this opportunity of rectifying the mistake: 85, 100, 363½, 956, 3095, and 4051·6 Prussian feet are equal to 87½, 103, 374, 983¾, 3184¾, and 4172⅓ English feet respectively.

The average cost of sinking, therefore, amounted to about £2. 1*s.* 9*d.* per foot English.

28, Jermyn Street,
February, 1875.

H. W. Bristow.

MR. CROLL ON THE OSCILLATIONS OF THE SEA-LEVEL DUE TO THE ADVANCE AND RETREAT OF THE ICE CAP.

SIR,—In my recently published book on "Valleys and their Relations to Fissures, Fractures, and Faults," in a foot-note on page 182, I refer to Mr. Croll's paper "On the Glacial Epoch" [GEOL. MAG. July and August, 1874], and point out that the oscillations in the sea-level "will account for the very uniform altitude of the ancient sea-beaches." As this note was added at the last moment, just previous to the book issuing from the press, it necessarily is not so explicit as it might be, and I find it has been taken exception to. Will you therefore allow me, through the medium of the GEOL. MAG., to supplement the note?

Although I believe Mr. Croll's theory to be correct, and that the sea in general rose and fell while the land for the most part remained comparatively stationary, yet I do not for a moment imagine that there were no oscillations of the land. On the contrary, such movements are proved in Ireland, as I have shown in different papers on its geology. Take, for instance, the margin and gravels of the "Esker Sea," which in some districts are at higher altitudes than in others. There are also the post-Drift faults, some being more recent than our newest Drift, which could not possibly have been formed without greater or less changes in the level of the land. Such changes in the level of the land do not seem to be denied by Mr. Croll, neither to me do they appear to affect his theory; as they, with a few exceptions, are mere bagatelles compared with the universal oscillations in the sea-level.

G. H. KINAHAN.

MISCELLANEOUS.

PHILLIPS'S GEOLOGY OF YORKSHIRE.—Subscribers to the new edition of the late Professor Phillips's "Geology of Yorkshire," Part 1, "The Yorkshire Coast," will be glad to hear that it has been placed in the hands of Mr. Robert Etheridge, F.R.S., F.G.S., and is now nearly completed; the last proof-sheets having been revised and the new map and plates nearly all coloured. It is hoped that by April the Professor's earliest and latest work will be issued.

THE BUSTI METEORITE.—Apropos of the "Chapter in the History of Meteorites" now appearing in this MAGAZINE, Dr. Flight desires us to state that, since the publication of the January Number, he has ascertained that a preliminary note on the Calcium Sulphide of the Busti aerolite, mentioned on page 16, was published in the *Brit. Assoc. Reports*, 1862, "Notes and Abstracts," Appendix ii., page 190.—EDIT. GEOL. MAG.

VOLCANIC ERUPTION IN JAVA.—"THE HAGUE, FEB. 3, 1875.—The Government has received a despatch from Batavia, of to-day's date, announcing an eruption of the volcano Kloet, in the island of Java, whereby great destruction has been caused at Blitar."

OBITUARY.

SIR CHARLES LYELL, BART.,

M.A., D.C.L., LL.D., F.R.S., F.L.S., V.P. GEOL. SOC. LOND.

On Monday, 22nd February, at his residence in Harley Street, and in his seventy-eighth year, Sir Charles Lyell passed peacefully from amongst us, after a long life of scientific labour, to his honoured rest.

To the outside world it may seem strange that the death of a man who was neither statesman, soldier, nor public orator, should arouse our sympathies so strongly, or that he should be so highly esteemed all over the world; but geologists know well what Lyell has done for them since he published the first volume of "The Principles of Geology" in 1830.

It is in the character of historian and philosophical exponent of geological thought that Lyell has achieved so much for our science; nor can we fail to remember that those clear and advanced views, for which he became so justly celebrated, were advocated by him forty-five years ago, at a time when scientific thought was still greatly trammelled by a strong religious bias, and men did not dare to openly avow their belief in geological discoveries nor accept the only deductions which could be drawn from them.

It was no small service which Lyell rendered to us when he publicly maintained that, in reasoning on geological data, it was impossible to restrict geologists to the limits of the Mosaic cosmogony, or to adopt for the past ages of geological time the chronology of Archdeacon Ussher.

Born at Kinnordy, his father's seat near Kerriemuir, in Forfarshire, on the 14th of November, 1797, Lyell received his early education at a private school at Midhurst, and completed it at Exeter College, Oxford, where he took his Bachelor's degree in 1819, obtaining a second-class in Classical honours in the Easter Term. On leaving the University, he studied for the Bar, but never practised that profession, his tastes having been led by Dr. Buckland's lectures to the study of Geology as a science. In 1824 he was elected an Honorary Secretary of the Geological Society of London, of which he was one of the earliest Fellows. On the opening of King's College, London, a few years later, he was appointed its first Professor of Geology. He had already contributed some important papers to the "Transactions" of the Geological Society, including one "On a Recent Formation of Freshwater Limestone in Forfarshire, and on some Recent Deposits of Freshwater Marl, with a comparison of recent with ancient Freshwater Formations, and an Appendix on *Gyrogonites*, or Seed Vessel of Chara;" also one "On the Strata of the Plastic Clay Formation exhibited in the Cliffs between Christchurch Head, Hampshire, and Studland Bay, Dorsetshire;" another "On the Freshwater Strata of Hordwell Cliff, Beacon Cliff, and Barton Cliff, Hampshire;" and an elaborate paper on the "Belgian Tertiaries." In 1827 he contributed to the *Quarterly* a review of Mr. Poulett Scrope's "Geology of Central France" (the perusal of which is said first to have stimulated him to prepare and publish "The Principles of Geology" on which his reputation as a philosophical writer mainly rests). These lesser works all showed a power of observation and of generalization which prepared the learned world for some greater and more important treatise from his pen, which should deal, not with local details, but with the general principles of the science. Nor were they disappointed when his *magnum opus*, "The Principles of Geology," appeared in three successive instalments, published respectively in 1830, 1832, and 1833. The work, subsequently enlarged into two volumes, has passed through numerous editions, and is still in as much demand as ever among students of the science. The work was subsequently divided into two parts, which have been published as distinct books—viz. "The Principles of Geology, or the Modern Changes of the Earth and its Inhabitants, as illustrative of Geology," and secondly, "The Elements of Geology, or the Ancient Changes of the Earth and its Inhabitants, as illustrated by its Geological Monuments." The substance of the last-named work has also been published under the title of "The Manual of Elementary Geology," a French translation of which was issued under the auspices of the famous Arago.

Already, some time previous to the publication of this work, Mr. Lyell had been chosen a Vice-President of the Geological Society; and in 1828 he had undertaken a journey into the volcanic regions of Central France, visiting Auvergne, Cantal, and Velay, and continuing his journey to Italy and Sicily. He published the results of this expedition in the "Edinburgh Philosophical Transactions," and also in the "Annales des Sciences Naturelles."

It was, however, the publication of his "Principles of Geology" that gave him that established reputation which he ever since continued to enjoy. "Which of us," asked Prof. Huxley, in his Anniversary Address to the Geological Society in 1869, "has not thumbed every page of the 'Principles of Geology'?" And he adds, "I think that he who writes fairly the history of his own progress in geological thought will not easily be able to separate his debt to Hutton from his obligations to Lyell." This cordial testimony of a fellow-labourer in the cause of scientific enlightenment exactly indicates Sir Charles Lyell's place in the history of that task. He was a man of singularly open mind, one of those who stand above their contemporaries and hail the dawn of new truths upon the world. His own works mark the progress of his own as well as of the public opinion on the great problems raised by scientific discovery, and he remained to the end of his life always ready for the reception of new facts, and for the corresponding modifications of opinion.

Sir Charles Lyell married, in 1832, Mary Elizabeth, eldest daughter of the late Mr. Leonard Horner, but was left a widower in 1873.

Sir Charles Lyell had travelled and seen much. Thus in early manhood he explored many parts of Norway, Sweden, Belgium, Switzerland, Germany, and Spain, including the volcanic regions of Catalonia. In 1836 he visited the Danish Islands of Seeland and Monen, to examine their Cretaceous and Tertiary strata. In 1841 he was induced to cross the Atlantic, partly in order to deliver a course of lectures on his favourite science at Boston, and partly in order to make observations on the structure and formation of the Transatlantic Continent. He remained in the United States for a year, travelling over the Northern and Central States, and extending his journey as far southward as Carolina, and northward to Canada and Nova Scotia, his exploration ranging from the basin of the St. Lawrence to the mouths of the Mississippi. On returning from this journey, he published his "Travels in North America," a work of considerable interest to other persons besides geologists, and showing that he could extend his observations to the stratification of society around him as well as that of the earth beneath his feet. He paid a second visit to America in 1845, when he closely examined the geological formation of the Southern States and the coasts that border on the Atlantic and the Gulf of Mexico, and more especially the great sunken area of New Madrid, which had been devastated by an earthquake 30 or 40 years previously. Upon reaching England, he published his "Second Visit to the United States," a companion to his former work. For his other scientific papers we must refer our readers to the "Proceedings" of the Geological Society, 1846–49, and its "Transactions."

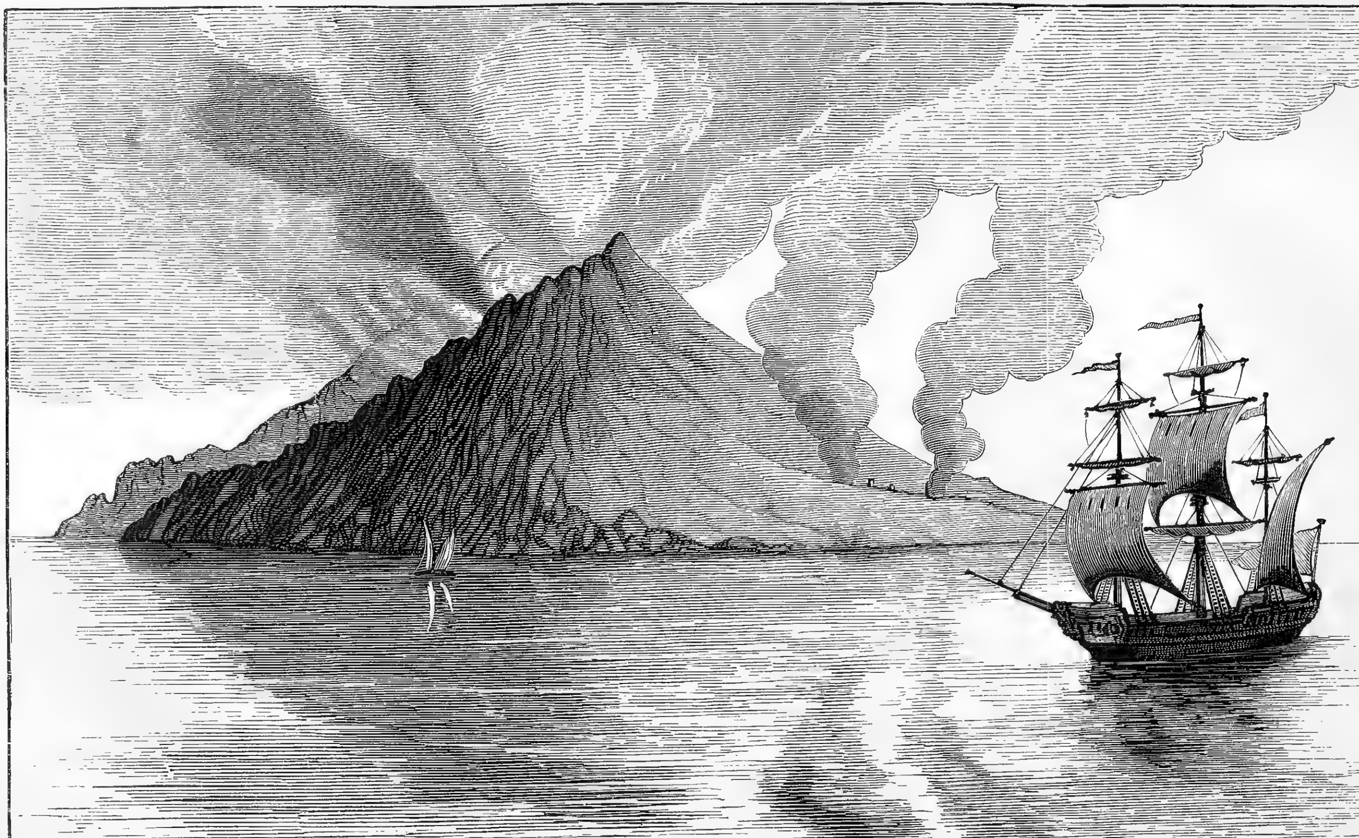
Late in life, about 10 or 12 years ago, Sir Charles Lyell published another very important work on "The Antiquity of Man," summarizing and discussing all the important facts accumulated up to that time in favour of the high antiquity of the human race, viewed from the standpoints of the archæologist, the geologist, and the philologist.

Numerous honours were conferred on Lyell in recognition of his services to Science. As far back as 1836 he was elected to the Presidential Chair of the Geological Society, to which he was re-elected in 1850. He received from Her Majesty the honour of knighthood in 1848, and in 1855 the honorary degree of D.C.L. of the University of Oxford was conferred upon him. He had been for many years a Fellow of the Royal Society, and in 1833 received one of the Royal Society's Gold Medals for his "Principles of Geology." In 1858 the Royal Society conferred upon him the highest honour at their disposal—the Copley Medal; and in 1864–5 he filled the Presidential Chair of the British Association for the Advancement of Science. He received the Wollaston Gold Medal from the Geological Society of London in 1865 (his continued official connexion with which had precluded his receiving it earlier). He was raised in 1864, on the recommendation of the then Prime Minister, Lord Palmerston, to a Baronetcy, which now becomes extinct by his decease. He was a Deputy-Lieutenant for his native county of Forfarshire.

Sir Charles Lyell has been so long and so honourably known among the scientific teachers of the time, that though he had arrived at his seventy-eighth year, and the period of his chief intellectual and physical activity had long passed away, probably even the younger men of the present generation will feel that science is poorer by his loss.

At the meeting of the Geological Society of London, held in the Society's room, Burlington House, Piccadilly, on Wednesday last (February 24th), the President, John Evans, Esq., F.R.S., before commencing the business of the meeting, alluded to the great loss which all present had sustained. He little expected, when speaking on the last occasion, at the Anniversary Meeting, of the services which Sir Charles Lyell had rendered to science for the previous fifty years, that he should have on the present occasion to announce and lament his irreparable loss. Sir Charles Lyell had been a true philosopher and a sincere friend. He had lived to see the extension of science which he had so eagerly desired realized. In future times, wherever the name of Lyell would be known, it would be as that of the greatest, the most philosophical, the most enlightened geologist of Great Britain or Europe.

In accordance with the wish of the Council of the Royal Society, Sir Charles Lyell will rest beside his old friend and fellow-labourer in science, Sir John Herschel, in Westminster Abbey.



View of Stromboli in 1768, as seen from the South-west. (*From Hamilton's Campi Phlegræi.* Plate xxxvii.)

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

No. IV.—APRIL, 1875.

ORIGINAL ARTICLES.

I.—Contributions to the Study of Volcanos.[1]

By J. W. Judd, F.G.S.

The Lipari Islands.—Stromboli.

(PLATE VIII.)

Presenting as it does the only example of a volcano in the phase of permanent moderate activity to be found in Europe, Stromboli must always have the strongest claims on the attention of geologists. Here may at all times be witnessed, in perfect security, those explosions produced by the disengagement of vapour in the midst of masses of liquefied rock, which, following one another at longer or shorter intervals, and taking place with greater or less violence, constitute a most striking feature in nearly all volcanic eruptions; and the causes, sequence and attendant phenomena of these outbursts can in the case of this volcano be most conveniently studied.

As might be anticipated from the less striking character of its action, Stromboli is less frequently mentioned by ancient writers than Vulcano; yet, as early as the fourth century before Christ, it is spoken of as being in a state of eruption, and references to it occur in the writings of Aristotle, Callias, Diodorus Siculus, Strabo and Cornelius Severus. Most interesting to the geologist, however, is the notice of the mountain by Pliny, who in the first century of our era describes it in terms which are still applicable to it at the present day.

But if the ancient accounts of this volcano are somewhat meagre, we are nevertheless fortunate in possessing the means of tracing very completely its history in modern times; during the last one hundred years numerous sagacious and trustworthy observers have visited the volcano, and given clear and accurate accounts of its condition. Their descriptions enable us to define the true character of the operations going on within its crater, to determine how far these operations are constant in their action, and to ascertain the limits of variation in the intensity, succession and results of its outbursts.

The general characters of the phenomena presented by Stromboli —"the lighthouse of the Mediterranean"—are well known to be as follows. The mountain, which is of conical form, rises directly from the deep waters of the Mediterranean to the height of more than 3000 feet above its surface; as the sea between the Liparis affords

[1] Continued from page 115.

soundings of from 300 to 700 fathoms, we must remember that the several islands are only the upper portions of great volcanic cones; at least one-half of the height of these, and by far the greater part of their bulk being concealed beneath the waves. Stromboli is completely made up of volcanic materials, and presents, not only some obscure traces of a greatly ruined crater at its summit, but numerous indications, in craters and lava-streams, of lateral outbursts on its flanks. But the most striking and interesting feature about the mountain is that on its north-western side there exists a crater in a state of constant activity, which, besides giving off vapours and gases,—either in explosive puffs, in continuous blasts, or in quietly issuing wreaths,—discharges at more or less regular intervals showers of scoriæ and volcanic ashes. Occasionally, also, small streams of lava flow from the crater itself or at some lower point on the mountain; and that a reservoir of incandescent material exists within the crater, is proved by the fact that, at night, the clouds of vapour and dust above the mountain reflect a fiery glow, either at the moment of the explosion and for a short interval afterwards, or, during times of more intense activity, almost continuously.

With regard to the position and relations of the several parts of the mountain, we have numerous measurements of accurate observers to guide us; and the recently published map of the Italian Government enables us to verify their various barometrical and other determinations. The active crater of Stromboli (Cratère la Fossa) is situated rather more than 600 feet below the summit of the mountain, that is, at a height of considerably more than 2000 feet above the level of the Mediterranean. The diameter of the crater is about 400 feet, and its bottom, which is several hundred feet below the rim on its southern or landward side, appears to be bounded by a crater-wall of but little elevation towards the sea. From this depressed portion of the crater-rim a long slope, called the Sciarra del Fuoco, leads down to the sea, with so steep an incline (35°) that all materials ejected from the crater are unable to rest upon it, but roll down into the sea. The Sciarra of Stromboli constitutes one of the most striking features of the mountain; its length from the crater to the sea-level is more than 1200 yards, and the breadth of its seaward edge is about 1000 yards. The walls bounding the inclined plane of the Sciarra, and which gradually converge towards the crater, are steep cliffs, seen to be composed of lava-streams, agglomerates, and dykes, presenting their usual relations with one another; indeed, the whole may be regarded as a miniature representative of the grand Val del Bove of Etna. Its general appearance is well seen in the view (copied from Abich) given as an illustration to Mr. Scrope's paper in the Volume of this Magazine for 1874, page 532. On the slope of the Sciarra may be observed several well-marked ridges of lava, which are either lava-streams that have flowed down it, or great dykes, formed by lava rising through fissures which have been produced in it during paroxysmal eruptions. We may remark that the Italian word "Sciarra" seems to be derived from the same root as our northern term "Scaur," and to have nearly the same significance. Having thus briefly noticed the salient features presented by Stromboli, the reader will have less difficulty in following the descriptions of the state of the volcano at different periods as borne witness to by various observers.

About the year 1744, according to an account received by Spallanzani, the volcano threw out such an enormous quantity of scoriæ as to cause a "dry place in the sea," which remained for some months as a hill rising above the waters, and then gradually disappeared. The probable interpretation of this is that, during a more than usually violent paroxysm of the volcano, a lateral cone was formed on the submerged flanks of the mountain, and, rising above the sea-level, was gradually destroyed by the action of the waves, in the same manner as in the well-known case of Graham's Isle.

In 1768, that able observer of volcanic phenomena, Sir William Hamilton, returning from a visit to Etna, was becalmed for three days among the Lipari Islands. Hamilton, at this time, not only saw the usual explosions of red-hot stones, but noticed that "some small streams of lava issued from its side, and flowed into the sea." A drawing by Signor Fabris, who accompanied Sir William Hamilton on this occasion, shows that, not only was the crater at this time in a state of rather violent activity, but that two lateral outbursts were taking place low down on the south-western flank of the mountain, not far from the hamlet of Ginostra. A copy of this drawing of Stromboli, made in 1768, is given in Plate VIII.

In 1770, according to Brydone, the volcano was more than usually active, and a submarine eruption took place near it. This author correctly describes the crater as situated at 200 yards below the summit of the mountain, but declares that while its action sometimes resembled that of Vesuvius (then in a state of moderate activity), "the explosions of which succeed one another with some degree of regularity, and have no great variety of duration," yet, at times, "a clear flame issues from the crater of the mountain, and continues to blaze, without interruption, for near the space of half an hour." Brydone had never seen a similar illumination of Vesuvius, except when the lava had risen to the summit of the mountain. In the descriptions of Brydone, then, we have evidence that in Stromboli and Vesuvius the usual features of their action were *temporarily* reversed: the former was passing through a violent paroxysm, while the latter exhibited a succession of subdued and almost rhythmical explosions. This is a most significant circumstance, and one which affords a complete refutation of the view that a *fundamental difference* exists between the nature, modes of action, and causes of the phenomena presented by these two volcanos.

Between the years 1766 and 1781, Dolomieu was twice in the vicinity of Stromboli during a time of sudden storm. He then saw the volcano making rapid explosions at intervals of two or three minutes, and throwing out stones, which fell into the sea at a distance of more than 200 feet, while the glow of light above the crater was very brilliant, and continued incessantly.

Very striking, however, were the differences in the state of the volcano which were noticed by the same distinguished observer when, in the calm and sultry weather of July, 1771, he visited the island, and ascended to the crater. Then the slight ejections of stones, which never rose more than 100 feet above the crater, while very few of them fell outside its rim, took place at regular intervals of seven or eight minutes; and the glow of light above the crater was seen only at the moment of the explosion, or for a few seconds afterwards.

In August, 1788, Spallanzani saw "the fires of Stromboli" at a distance of 100 miles, the explosions at that time taking place at very irregular intervals. On the 1st and 2nd of October, in the same year, during very stormy weather, he found the eruptions of the mountain were so violent, that the whole island and the sea around were lighted up at times by them; the houses were shaken by the violent concussions of the air; and ashes fell in the inhabited parts of the island, two miles distant from the crater. Yet the islanders assured Spallanzani that much more violent outbursts sometimes took place. On the 3rd of October, when the weather fell calm, much slighter explosions were seen to take place at intervals of not more than two or three minutes. On the night of the 4th, when Spallanzani visited the crater, the ejections were found taking place in the same rapid manner, but with very varying degrees of intensity. The account given by the great Italian philosopher of what he witnessed within the crater is most graphic and interesting. On its western side a very great number of fumaroles were seen discharging jets of steam, while deposits of yellow salts were being formed round their orifices; but on its eastern side one large mouth poured forth a continuous column of vapour, about 12 feet in diameter. In the centre of the crater, however, still more striking appearances were exhibited, for here a funnel-shaped tube was seen containing liquid lava. This incandescent mass was agitated by two movements, "one intestine, whirling and tumultuous, the other that by which it was impelled upwards and downwards." This vertical motion, the utmost range of which was estimated at 20 feet, was sometimes slow, and at others more sudden; but, on its reaching a certain height, large bubbles were seen to collect on the surface of the glowing mass, and these, bursting with a sharp report, carried innumerable fragments of the liquid rock in a fiery shower into the air. After the explosion, the lava was seen to sink again in the tube, to recommence its rise after a short interval. On one occasion, however, Spallanzani witnessed a most interesting occurrence in the crater of Stromboli: the lava sinking lower than usual in the tube, while the fumaroles began to discharge with a deafening roar, their orifices at the same time becoming red-hot. This striking phenomenon soon ceased, however, the normal action of the crater being resumed; and Spallanzani was assured by his guides that this peculiar condition of the crater only rarely occurred, and was never of long duration. In connexion with this very remarkable circumstance, it may be well to recall the fact that, during the recent eruption in the crater of Vulcano, the fumaroles ceased to discharge, but that on its termination their activity was renewed with greatly increased violence.

Passing over the account of Ferrara in 1810, as well as some other descriptions of the features of the volcano in its ordinary condition of subdued activity, we will proceed to notice the admirably clear descriptions of an English naval officer, who, during the year 1813, was constantly cruising about these islands in a gun-boat, being employed in constructing the charts of the Mediterranean. The fact that he was not engaged in any special geological researches, and does not seem to have been acquainted with the writings of either Dolomieu or Spallanzani, gives his testimony on the subject all the value of that of a perfectly independent witness; and it will only be necessary to mention that this young officer subsequently became well known in the scientific world as Admiral W. H. Smyth, to satisfy our readers as to his competency and accuracy.[1]

Smyth, who ascended the mountain and spent a part of the night beside the crater, thus describes what he saw:—"When the smoke cleared away, we perceived an undulating ignited substance, which at short intervals rose and fell in great agitation; and, when swollen to the utmost height, burst with a violent explosion and a discharge of red-hot stones, in a semi-fluid state, accompanied with showers of ashes and sand, and a strong sulphurous smell. The masses are usually thrown up to a height of from 60 or 70 to 300 feet; but some, the descent of which I computed to occupy from 9 to 12 seconds, must have ascended above 1000 feet. In the moderate ejections, the stones in their ascent gradually diverged, like a grand pyrotechnical exhibition, and fell into the abyss again; except on the side near the sea, where they rolled down in quick succession, after bounding from the declivity, to a considerable distance in the water. A few fell near us, into which, while in the fluid state, we thrust small pieces of money as memorials for friends."

Valuable as is Smyth's evidence as to the nature of the phenomena displayed within the crater of Stromboli, his testimony to the fact that its eruptions are sometimes, and especially during stormy weather, of a much more violent character than ordinary, is equally clear, as the following passage will show:

"I was once going over, in my gun-boat, from Milazzo to Stromboli, when a furious south-east wind arose, and rendered it impossible to anchor before San Bartoli, where, on approaching, I observed the spray of the surf carried even to the houses: the only refuge to save us from being blown over to Calabria, then occupied by Murat, was to run almost under the crater in a nook of Schiarazza Point, where, for two nights and days, we rode in a state of partial security as to winds and weather; but certainly not without considerable danger from the incessant showers of red-hot stones that were hurled aloft from the crater with amazing rapidity, and most of which fell very near us, while some of them exploded in the air with a whizzing sound like the fragments of bomb-shells after bursting. The explosions followed each other in quick succession (not more than 5 to 10 minutes elapsing between) with a report like distant artillery; the moment of ejection was accompanied by brisk rattling detona-

[1] I am indebted to Mr. Warington W. Smyth, F.R.S., for giving me the date of his father's observations on Stromboli.

tions, and a full glare of fire, illuminating the storm at intervals, and presenting an awful and magnificent spectacle. At times, however, when the wind shifted a point or two, our admiration was checked, and we were obliged to run below, to avoid a thick cloud of minute sand and ashes, that instantly covered the vessel and filled her with a suffocating heat."

A little later Stromboli was visited by two English geologists, each of whom had paid particular attention to the character of volcanic action, and who were therefore well qualified to describe what they saw.

In May, 1819, Mr. Poulett Scrope ascended the mountain, and thus describes what he witnessed: "Two rude openings show themselves among the black chaotic rocks of scoriform lava which form the floor of the crater. One of these is to appearance empty; but from it there proceeds, at intervals of a few minutes, a rush of vapour with a roaring sound, like that of a smelting furnace when the door is opened, but infinitely louder. It lasts about a minute. Within the other aperture, which is perhaps 20 feet in diameter, and but a few yards distant, may be distinctly perceived a body of molten matter, having a vivid glow even by day, approaching to that of white heat, which rises and falls at intervals of 10 to 15 minutes. Each time that it reaches in its rise the lip of the orifice, it opens at the centre, like a great bubble bursting, and discharges upwards an explosive volume of dense vapour, with a shower of fragments of incandescent lava and ragged scoriæ, which rise to the height of several hundred feet above the lip of the crater. Many of the fragments do not reach so high. Part of them fall back within its circuit to be again rejected. A considerable proportion, however, falling on the steep talus already described on the north side of the vent, roll or slide down into the sea; and it is evident, from the crater continuing to retain its depth and form, that sooner or later, after perhaps repeated ejection, all must find their way there, to be distributed over the bottom of the Mediterranean."

As bearing on the variations in the intensity of action of the volcano, Mr. Scrope adds: "In the foul weather of winter I was assured by the inhabitants that the eruptions are sometimes very violent, and that the whole flank of the mountain immediately below the crater is then occasionally rent by a fissure, which discharges lava into the sea, but must very soon be sealed up again, as the lava shortly after finds its way once more to the summit and boils up there as before."

A few years later (in 1824?) Dr. Daubeny visited Stromboli, but did not approach sufficiently near to the crater to observe its phenomena very minutely. He says: "The minor explosions were in general almost continuous, but that the greater ones, which alone were audible below, take place at intervals of about seven minutes: the latter are sufficiently terrific."

In 1825 Stromboli was visited by M. Biot, and in 1829 by M. Virlet and the commission despatched to the Morea by the French Academy. Each of these authors speaks of the explosions taking place at short intervals.

In 1831 the phenomena of this interesting volcano were studied at nearly the same time, but quite independently, by the two geologists who, in Germany and France respectively, have done more perhaps than any others for the promotion of the study of volcanic phenomena, more especially by combating errors, which in those countries so long retarded its progress. I refer to Friedrich Hoffmann and Constant Prevost. The former author has given us a detailed account of his researches, and the latter has borne witness to its substantial accuracy.

Hoffmann remained for three weeks in Stromboli at the end of 1831 and the beginning of 1832; he on three different occasions spent a considerable time on the edge of the crater, and minutely describes what he witnessed. He was convinced both from what he heard and saw, that the openings at the bottom of the crater vary in size, number and condition from time to time; shortly before his visit there were no less than seven openings in the crater, but when he examined it himself, there were but three: but these were seen to be quite distinct from one another both in position and in the nature of their action.

The largest of the openings occupied the centre of the crater floor, and gave forth vapours only, which produced yellow crusts on its sides. To the south-west of this, on the same level with it, and nearly under the crater-wall, another mouth about 20 feet in diameter was seen, which discharged abundant white clouds, and gave origin to constant smaller or greater explosions. In the interior of the glowing red throat of this chimney, a fluid column of lava could be seen moving up and down, and perhaps sinking to a depth of 20 or 30 feet below its summit. Through this column of liquid lava bubbles of steam burst with a noise which resembled that of a furnace when the door is opened; the puffs taking place regularly at intervals of about a second, and giving rise to the formation of globes of vapour, which, in issuing from the mouth of the aperture, carried up bladders of the liquid lava. This action continued often for more than a quarter of an hour, and then suddenly a louder detonation would be heard, which was followed by a violent escape of steam from the aperture and the ejection of a thousand fragments of glowing lava to a great height. Where the crater joins the steep slope of the Sciarra, a third and much smaller opening was seen, from which a little stream of lava, like a perennial fountain, was constantly issuing; it flowed down the Sciarra towards the sea, which, however, it did not reach, becoming solid before it arrived at the bottom; some portions, however, of the congealed mass were continually becoming detached and rolling down into the water. The position of this lava-stream on the Sciarra is represented in Hoffmann's drawing of Stromboli.

On the 25th of July, 1836, Abich visited the crater of Stromboli. He saw in the midst of the crater a throat 60 or 70 feet in diameter, in which glowing lava could be perceived moving up and down; and several smaller openings were also visible by the side of it. Another mouth at the junction of the crater with the Sciarra discharged showers of stones at intervals of 6 or 7 minutes; the latter had formed a miniature cone about 20 feet high on the depressed edge of the crater-ring. The outbursts from this mouth were from time to time followed by the gushing forth of a little stream of lava from a cleft on the Sciarra, a little below the northern rim of the crater. The intervals between the explosions at the time of Abich's visit appear to have been very constant. Besides the larger mouths, there were numerous fumaroles within and about the crater.

In June, 1844, the crater of Stromboli was visited by MM. de Quatrefages, Edwards, and Blanchard. The first of these gives the following description of the state of the volcano at that time. The crater, which was well marked, presented several depressions, and *six very distinct* mouths were clearly visible in it. Two of these gave off steam exclusively. A third, on the right of the crater, produced an almost constant fountain of small, glowing fragments, which fell back within it; the action of this bocca was attended with a singular noise. On the right, three other mouths gave rise to intermittent explosions; two of these always acting simultaneously, at intervals of five or six minutes; while the sixth mouth appeared to be quite independent, and its much louder and more violent explosions occurred at intervals of 10 or 12 minutes. The stones thrown out by the latter rose to a height of more than 600 feet, those from the other two intermittent mouths to less than half that height. There was evidently a connexion between the first five apertures, for the action of the three constantly discharging vents was accelerated just before the explosions of the two smaller intermittent mouths; but the sixth and most powerful vent appeared to produce its explosions quite independently of all the others.

(To be continued in our next Number.)

II.—A Chapter in the History of Meteorites.

By Walter Flight, D.Sc., F.G.S.,

Of the Department of Mineralogy, British Museum;
Assistant Examiner in Chemistry, University of London.

(*Continued from page* 123.)

(PLATE IV.)

1870. Meteoric Iron from Ovifak, Greenland. (Continued.)

The following rocks from Disko Island have been examined by Nauckhoff:

I. Section of a six-sided basalt column from Brededal, east side of Skarfvefjell, and about 10′ E. of Godhavn; showing compact dark greyish-green ground-mass with crypto-crystalline texture; under the microscope crystals of a felspar, augite and magnetite are recognized. Fusible before the blowpipe.—II. Basalt from the east side of the ridge at Ovifak, where the iron and breccia were found. Fusible before the blowpipe.—III. Rock occurring in rounded masses, with green foliated crust, in the basalt ridge, and inclosing spangles and spherules of iron, some 6—7 mm. in diameter; these exhibit Widmannstättian figures. Appears to be a very finely granular mixture of a felspar with a small amount of a green mineral, probably augite, and imperfectly crystallized magnetite, which latter usually surrounds the spangles of iron; olivine is only occasionally met with, in grains the size of a pea. Melts with difficulty before the blowpipe.—IV. Very hard brown-coloured mass inclosing rock in which iron spangles are found; it closely resembles III. The ground-mass consists of a felspar, probably anorthite, the crystals of which are occasionally large, and show marks of twinning, and a great number of reddish

Meteoric Iron, found 1870, at Ovifak, Disko, Island, Greenland

octahedra closely resembling spinel. Small particles of a greenish mineral of the appearance of augite are also to be distinguished. Spangles of iron are very rarely found in the felspar; and magnetite is apparently absent. Melts very slowly before the blowpipe.—V. Rounded lump of grey rock from the basalt ridge; it was covered with a dark green vesicular crust, from 15 to 20 mm. thick. Through the ground-mass, which appears to consist of a felspar, were disseminated numerous brilliant greyish scales, besides some very black magnetite or graphite. Augite sparsely distributed; abundance of red spinel in some parts, none in others. Melts with great difficulty before the blowpipe.—VI. The dark greenish-brown crust of V, closely resembling that of the rounded masses III. It consists of a felspar inclosing a brown and a green augite-like mineral, and, in places, clusters of granules of spinel. Melts with great difficulty before the blowpipe.—VII. Light grey foliated rock from Ovifak, the exact circumstances of the occurrence of which are not known. The ground-mass consists of a mixture of a felspar with a grey, finely foliated mineral with graphitic lustre. Red spinel is met with abundantly in both constituent minerals. This variety of rock, like those from the ridge, is covered with a rust-like crust. It breaks easily, and always parallel to the scales. Before the blowpipe it melts with difficulty on the edges.—VIII. Compact, slightly-weathered breccia, filling a fissure two to three inches wide in the basalt ridge, parallel to which it runs. It is a black granular mass, devoid of metallic lustre, and incloses fragments, some with edges sharp and angular, others with the corners rounded, of a rock exactly like that forming the ridge.—IX. Loose, much-weathered breccia, from the top of the ridge, in irregularly-shaped fragments. It can be broken in pieces with the hand, is much rusted, and closely resembles the product of the oxidation of the metal blocks. Like the preceding specimen, it incloses rounded fragments of the rock forming the ridge. The specific gravity is about midway between that of iron and of magnetite.—X. The broken-up basalt, resembling that of the ridge, inclosed in the weathered breccia IX.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
Silicic acid	49·18	48·04	42·72	34·72	36·59	44·94	37·92	1·04	0·81	41·25
Titanic acid	0·52	0·39	trace	—	—	—	—		—	0·34
Phosphoric acid	0·13	0·07	trace	—	—	—	—	0·12	0·12	—
Iron sesquioxide	5·52	6·89	1·64	4·88	—	—	—		—	16·18
Alumina	13·52	13·13	16·01	31·83	19·18	22·20	32·36	2·31	2·92	13·06
Chromium oxide	—	—	—	—	—	—	0·08		—	—
Magnetite	—	—	—	—	—	—	—	52·51	77·39	—
Iron protoxide	10·31	11·14	14·27	5·53	14·85	9·45	4·02		—	10·78
Manganese protoxide	0·28	0·11	trace	—	0·29	—	0·19		—	0·25
Nickel and Cobalt oxides	—	—	—	—	—	—	—	1·17	0·82	—
Magnesia	6·83	5·17	7·93	9·35	7·24	4·98	2·86	0·02	trace	6·41
Lime	11·51	10·87	10·10	10·19	8·73	11·01	11·57	0·30	0·20	7·97
Soda	1·84	2·83	1·65	1·00	0·79	1·86	1·48	0·08	0·11	1·54
Potash	0·06	0·06	0·13	0·27	trace	0·06	trace	trace	trace	0·03
Iron	—	—	4·57	0·09	5·01	1·11	—	28·36	7·73	—
Nickel	—	—	0·44	—	0·25	—	trace	1·22	1·81	—
Cobalt	—	—	trace	—	trace	—	trace	0·30	0·33	trace
Copper	trace		trace		trace	trace	trace	0·08	0·30?	trace
Hydrogen	—	0·25?	0·30?	0·29?	0·31?	0·31?	0·24?	0·38	0·51	0·49
Carbon	—	0·79	0·30	0·53	2·55	3·35	6·90	3·52	2·33	0·86
Sulphur	—	0·98	0·32	—	trace	trace	0·77	0·34	trace	trace
Chlorine	trace	trace	0·08	0·12	0·23	0·20	trace	trace	0·14	0·25
Water	0·34	—	—	—	—	—	—		—	—
Residue	—	—	—	—	—	—	—	9·64	3·71	—
	100·04	100·72	100·46	98·80	96·02	99·47	98·39	100·39	99·23	99·41
Specific Gravity	3·016	3·024	3·169	2·942	3·141	2·927	2·761	4·560	6·570	3·358

Tschermak examined two microscopic sections of the Ovifak rocks, and compared them with sections of the meteorites of Jonsac, Juvinas, Petersburg, and Stannern, which consist chiefly of augite and anorthite, with little or no nickel-iron; they form a class which G. Rose termed 'eucritic.' Both sections exhibit a crust, as meteorites possess; it is, however, so altered by oxidation, that it is not possible to determine whether it is the fused crust usually noticed on a meteorite. The crystals of felspar, which, according to Nauckhoff's analyses, must be regarded as anorthite, are fully developed; they penetrate the augite, iron, and magnetite, and must evidently have been formed before them. They are completely transparent, and have but few and large cavities, which are filled, partly with black granules, partly with a brown substance of irregular form; some traversing the length of the crystals are filled with a transparent glassy substance. The augite is of a light greenish-brown hue, traversed here and there by flaws; it fills gaps between the other constituents, as has been often observed in dolerites and diabases, and encloses individual black grains. In the section containing iron the colourless felspar encloses a black or brown substance running the length of the crystals, or dust-like fine black granules, or larger round transparent bodies of a violet colour, which may be the mineral Nauckhoff regards as spinel. Side by side with the felspar, brown grains, less numerous than in the former section, are seen, and these are probably augite. Black particles, moreover, occur, which by reflected light appear to be semi-metallic, and are probably magnetite, as well as others that are likewise black, but devoid of lustre, which seem to be graphite. A few small grains of troilite were also recognized. In the second section, which bore a general resemblance to the first, the felspar crystals were larger, the matrix being made up of finer crystals. In some of the felspar crystals cloudy pale brown patches were observed, which, when viewed with a higher power, were found to be due to numberless minute elongated inclosed granules lying in parallel position, or to others that were shorter and more rounded. These appearances recall those noticed in eucritic meteorites, like that of Jonsac, except for the fact that the inclosed particles are of smaller size. The larger cavities in the felspar are filled in the same manner as in the other rock section from Ovifak. The structure of eucritic meteorites is tufaceous; that of the Ovifak rock very compact. This distinction, however, has often been observed in meteorites. Many chondritic meteorites are tufaceous; while others, having similar chemical composition, like the aerolites of Lodran and Manbhoom, are compact and crystalline. The augite of the Ovifak rocks has not the characteristically filled cavities observed in that of certain eucritic meteorites; but in the augite of some meteorites, as those of Shergotty and Busti, for example, they are equally wanting.

The meteorites of Ovifak in some respects resemble the carbonaceous meteorites, though they differ greatly from them in other characters: especially in the appearance of both metallic and rocky portions. They form a new type in the series of meteoric rocks, and fill the gap that has hitherto separated the carbonaceous from other meteorites.

If some differences are to be traced between the remarkable rocks and irons of Ovifak and known meteorites, others still greater present themselves, when we compare the Greenland masses with terrestrial rocks, even with the basalts and diorites, near which it might be proposed to class them, on account of the occurrence in them of magnetite, and of the crystalline arrangement of their silicates. Iron has not hitherto been found as metal inclosed in basalt, except on very rare occasions (as by Andrews in the basalt of Antrim,[1] and then only in fine particles, and apparently not alloyed with nickel and cobalt), while troilite is a meteoric mineral, and has never been met with in a terrestrial rock.

But if the weight of evidence favours the assumption that these masses are of meteoric origin, there remain the following considerations, to which attention has been drawn by Rammelsberg, supporting the view that they may possibly have been erupted.

Of the rocks composing the globe, the greater portion accessible to us have been modified by the action of water. There is one class of which this cannot be said: the molten masses brought to the surface by volcanos, the various rocks we term "lava." However they may differ as regards constituent minerals, they have amongst them a family resemblance, and it is with them that the meteoric rocks may be compared. The old lavas of Iceland and Java consist of augite and anorthite, as do the meteorites of Juvinas, Jonsac and Stannern. The "bombs" of the prehistoric volcanos of the Eifel are composed of olivine, augite, bronzite and chromite, minerals that are commonly met with in meteorites. Hence arises the question: Are these masses, so similar in their lithological characters to the meteorites, samples perhaps of the inner unchanged nucleus of our planet? Does the original mass of the earth differ in point of magnitude only from the fragments which yield to its attraction?

The mean density of the earth is greater than that of the minerals composing the rocks of the outer crust. The volcanic rocks and the meteorites, which in point of chemical constitution are basic, are alike denser than this crust. The presence of metallic iron, a characteristic feature of meteorites, points to the absence of water and free oxygen as one of the essential conditions for their formation. Terrestrial rocks rarely contain iron, but it is replaced by an oxidized form of iron,—magnetite. Only in combination with platinum is it found in the metallic state. May the rocks of the interior of our globe contain this, the most important of all the metals, in an uncombined condition?

It has been pointed out by Daubrée that a region like Greenland, where doleritic rocks cover so wide an area, appears in a marked degree to present the conditions necessary and favourable for the upheaval of masses from very considerable depths.

Another phase of the question to which he directs attention

[1] A. E. Reuss detected the presence of iron in some Bohemian basalts by Andrews' method. (*Kenngott's Uebersicht Result. Min. Forschungen*, 1859, 105.)

should also be mentioned. It appears not improbable that the basalt of Greenland, which contains more than 20 per cent. of iron oxide, may during eruption have undergone reduction such as he imitated in his laboratory some years since. This theory is the more admissible from the fact that in the region under consideration, between Lat. 69° and 72°, numerous large beds of lignite, as well as graphite, occur, especially in the island of Disko, in which Ovifak is situated.

In a paper on the anomalous magnetic characters of iron sesquioxide, prepared from meteoric iron, recently communicated to the French Academy by Dr. Lawrence Smith, he announces that the investigation of this iron, on which he is at present occupied, has convinced him that the Ovifak metallic masses are of terrestrial origin.

The fact, observed by Nordenskjöld and Wöhler, of the evolution of a large amount of gas by Ovifak iron when heated, led these observers to the conclusion that it could never have been exposed to a high temperature. Tschermak, however, points out that this phenomenon has only been observed in experiments conducted at ordinary pressure, and it must not be forgotten, he maintains, that these masses, though surrounded by a heated medium, were at the same time subjected to the superincumbent pressure of a vast layer of fluid basalt. They may, moreover, have originally had a different composition, and the oxygen, which plays so essential a part in the gaseous evolution, may have been taken up subsequently during exposure to the atmosphere.

Daubrée draws attention to a reaction, mentioned by Stammer, and thoroughly investigated by Grüner, that, in the presence of iron oxide, or even of iron under certain circumstances, carbonic oxide breaks up, depositing carbon, partly in combination with iron, partly in intimate mixture with iron oxide; and that this reaction, which has been found to occur at 400°, does not take place at very high temperatures.

Nordenskjöld's paper is illustrated by a plan of the shore at Ovifak, where the irons were found, and by a sketch made on the spot by Nordström of the three largest masses, showing them partly immersed; while in a plate are given representations of seven of the blocks—one showing very distinctly the manner in which the metal is rent during oxidation. Nauckhoff has appended to his paper in the *Mittheilungen* a drawing of the gangue, indicating the position of the smaller pieces of iron and the breccia. Four excellent photographs of the larger masses have been published by the Hofphotograph Jaeger, in Stockholm.

One of the largest blocks, weighing 10,000 lbs., was offered for sale in New York for 12,500 dollars in gold, and smaller specimens at eight dollars per lb.

As is well known, implements of meteoric iron have from time to time been found in the possession of the Esquimaux. Some recent specimens, inserted in bone handles, from Esquimaux kjœkkenmœddings, were described by Steenstrup at the *Congrès international d'Anthropologie et d'Archéologie prehistoriques à Bruxelles* (Session de 1872). For figures of these implements see *Matériaux pour l'histoire primitive et naturelle de l'Homme.* 9 Année, 2e Série, Tome IV. 2e Livraison, 1873, 65.

Cryoconite found 1870, July 19th—25th, on inland ice, east of Auleitsivik Fjord, Disko Bay, Greenland.—Meteoric metallic particles found in snow, which fell:—1.) 1871, December—Stockholm.—2.) 1872, March 13th—Evoia, Finnland.—3.) 1872, August 8th—Lat. 80° N.; Long. 13° E.—4.) 1872, September 2nd—Lat. 80° N.; Long. 15° E.[1]

Early in December, 1871, there was a heavier fall of snow in the neighbourhood of Stockholm than any that had occurred there within the memory of living persons; and it presented to Nordenskjöld an opportunity of determining whether the snow brought cosmical matter to the earth's surface. A cubic metre of apparently pure snow, collected towards the end of the fall, left on melting a small black residue. From some of this substance, when heated, a liquid product distilled over; a portion when burnt left a red ash; while a magnet extracted particles which, when rubbed in an agate mortar, exhibited metallic characters, and on being treated with acid proved to be iron. Although the possibility must be admitted that this material may have been derived from the chimneys and iron roofs of the city, already covered with a thick layer of snow, the result was sufficiently interesting to make it desirable that a similar experiment should be tried with snow falling remote from towns. For this purpose snow was collected on the 13th March, 1872, by Dr. Karl Nordenskjöld at Evoia, in Finnland, to the north of Helsingfors, and lying in the centre of a large forest. It was taken from off the ice of the Rautajerwi, at a spot which is separated by a dense wood from the houses of that northern station. When melted, this snow yielded a soot-like residue, which under the microscope was found to consist not only of a black carbonaceous substance, but white or yellowish-white granules, and from it the magnet removed black grains, that when rubbed in a mortar were seen to be iron. Here again the material was too small in amount to allow of a determination of the presence of nickel and cobalt; in other words, to establish the meteoric origin of the metal. The Arctic Expedition of 1872 presented an opportunity for the collection of snow in a region as far removed as possible from human habitation. On the 8th August, the snow covering the drift-ice at Lat. 80° N. and Long. 13° E., was observed to be thickly covered with small black particles, while in places these penetrated to a depth of some inches the granular mass of ice into which the underlying snow had been converted. Magnetic particles were abundant, and their power to reduce copper sulphate was established. Again, on the 2nd September, at Lat. 80° N. and Long. 15° E., the ice-field was found covered

[1] A. E. Nordenskjöld. Redogörelse för en Expedition till Grönland år 1870, 28. (See also Geol. Mag. IX. 356.) *Compt. rend.*, lxxvii. 463: *Jour. Prakt. Chem.*, ix. 356. *Pogg. Ann.*, cli. 154.

with a bed of freshly fallen snow, 50 mm. thick, then a more compact bed 8 mm. in thickness, and below this a layer 30 mm. thick of snow converted into a crystalline granular mass. The latter was full of black granules, which became grey when dried, and exhibited the magnetic and chemical characters already mentioned; they amounted to 0·1 to 1·0 millegramme in a cubic metre of snow. Analysis of some millegrammes enabled Nordenskjöld to establish the presence of iron, phosphorus, cobalt, and probably nickel. The filtrate from the iron oxide gave a small brown precipitate, which gave a blue head with borax. The portion insoluble in acid consisted of fine angular colourless matter, containing fragments of diatoms. This dust from the polar ice north of Spitzbergen bears a great resemblance to the remarkable substance, cryoconite,[1] which was found in Greenland in 1870, very evenly distributed in not inconsiderable quantity on shore-ice, as well as on ice thirty miles from the coast and at a height of 700 metres above the sea. The dust of both localities has probably a common origin.

The cryoconite is chiefly met with in the holes of the ice, forming a layer of grey powder at the bottom of the water filling the holes. Considerable quantities of this substance are often carried down by the streams which traverse the glacier in all directions. The icehills which feed these streams lie towards the east, on a slowly rising undulating plateau, on the surface of which not the slightest trace of stone or larger rock masses was observed. The actual position of this material, to which Nordenskjöld has given the name of cryoconite (*κρύος* ice, and *κόνις* dust), in open hollows on the surface of the glacier, precluded the possibility of its having been derived from the ground beneath.

The grey powder contained a not inconsiderable amount of organic matter, which, even at the low temperature of the ice, undergoes putrefactive decomposition. A quantity, amounting to from two to three cubic metres, which was lying in the dried-up bed of a glacier stream, emitted a very offensive odour, bearing some resemblance to that of butyric acid.

When examined with the microscope, the chief constituent of this powder appears to consist of colourless, crystalline, angular, transparent grains, among which are a few yellow and less transparent. Some had distinct cleavage-surfaces, and were possibly a felspar; other crystal fragments, having a green colour, were probably augite; while other black, opaque particles could be removed with a magnet. These foreign constituents, however, are present in so small a quantity that if all the white grains consist of one and the same mineral, it may be regarded as homogeneous. The specific gravity of this mineral is 2·63; the hardness apparently inconsiderable, and the form probably monoclinic. It resists the action of acids: by long digestion with sulphuric acid 7·73 per cent., with hydrochloric acid 16·46 per cent. were dissolved. Lime carbonate was not present. According to Lindström's analysis, it consists of:

[1] A. E. Nordenskjöld. An Account of an Expedition to Greenland. Geol. Mag. Vol. IX. p. 355.

Silicic acid	62·65	Potash	2·02
Phosphoric acid	0·11	Soda	4·01
Alumina	14·93	Chlorine	0·06
Iron oxide	0·74	Water (hygroscopic)	0·34
Iron protoxide	4·64	Organic matter and combined water[1]	2·86
Manganese protoxide	0·07		
Lime	5·09		
Magnesia	3·00		100·12

This composition corresponds with the formula :

$$2RO,SiO_2 + Al_2O_3,3SiO_2 + H_2O.$$

The origin of this cryoconite is highly engimatical. That it is not a product of the weathering of the gneiss of the coast is shown by its inferior hardness, indicating the absence of quartz, the large proportion of soda, and the fact of mica not being present. That it is not dust derived from the basalt area of Greenland is indicated by the subordinate position iron oxide occupies among the constituents, as well as by the large proportion of silicic acid. We have then to fall back on the assumption that it is either of volcanic or cosmical origin.

That dust can be carried enormous distances has been well established. Darwin[2] refers to instances of dust having fallen on ships when more than a thousand miles from the coast of Africa, and at points sixteen hundred miles distant in a north and south direction. If the Greenland dust were volcanic, it would probably have been wafted from Iceland or Jan Mayen, or some as yet unknown volcanic region in the interior of Greenland. Nordenskjöld found it to bear the closest resemblance under the microscope to the ash of Vesuvius (1822), and a specimen of that which fell at Barbadoes and probably came from St. Vincent. Looked at in the mass, however, it is at once seen that the volcanic ash is of a brownish red ; the cryoconite is grey. The magnet when placed in contact with the Vesuvian ash extracted nothing ; out of that from Barbadoes it drew magnetic particles, which, however, were not metallic, nor did they contain nickel or cobalt.

The cryoconite, nevertheless, whencesoever it comes, contains one constituent of cosmical origin. Nordenskjöld extracted, by means of the magnet, from a large quantity of material, sufficient particles to determine their metallic nature and composition. These grains separate copper from a solution of the sulphate, and exhibit conclusive indications of the presence of cobalt (not only before the blowpipe, but with solution of potassium nitrite), of copper, and of nickel, though in the latter case with a smaller degree of certainty, through the reactions of this metal being of a less delicate character. Moreover, ammonia removes from cryoconite a humus-like substance that, among other characteristics, in its powers of resisting powerful oxidizing reagents, closely resembles the organic compound found in he residue of Ovifak iron after treatment with acid.

[1] This passed off when the mineral was heated to temperatures ranging from 100° to a red heat.

[2] C. Darwin. *Journal of Researches. . . . . Voyage of H.M.S. Beagle*, new ed. 1870, p. 5.

Hail, which fell at Stockholm in the autumn of 1873, was found by Nordenskjöld to contain grey metallic particles that reduced copper from its sulphate. Although the roofs of the buildings surrounding the Academy, in the courtyard of which these hailstones fell, are of iron, the grains were rounded, and of light colour, instead of a reddish-brown, and the observation is of sufficient interest to allow of its being placed on record.

It has been shown that small quantities of a cosmical dust, containing iron, cobalt, nickel, phosphorus, and carbonaceous substances, fall with other atmospheric precipitates on the earth's surface. Nordenskjöld, in his paper, alludes to the theory, already advanced, we believe, by Haidinger, that this deposit may play an important part in the economy of nature in supplying phosphorus to soils already exhausted by the growth of crops. His observations, moreover, are of value through the light they throw on the theories of star-showers, auroræ, etc. The small but continuous increase of the mass of our planet which appears to take place may lead students of geology to modify the view at present held, that from the time of the first appearance of vegetable and animal life upon our planet it has undergone no change, in a quantitative sense—in other words, that the geological changes which have occurred have been confined to a difference in the distribution of material, and not to the introduction of new material from without.

When the instances of the fall of soot-like particles, blood-rain, sulphur-showers, etc., which have from time to time been described, are considered, the view pronounced by Chladni, that these phenomena are due to the precipitation of large quantities of cosmical dust, appears of great import. The black carbonaceous substances which fell with the Hessle meteorites, and coated some of them, may be quoted as an illustration. Some meteorites, moreover, are so loose and friable in texture that they are very readily reduced to powder, as the Ornans meteorite (1868, July 11th), while that which fell at Orgeuil (1864, May 14th) breaks up when placed in water. If this stone had not fallen on a day when the atmosphere was dry, portions, if not the whole of it, would probably have reached the earth's surface in the form of powder. These atmospheric deposits may have a very varied composition. The dust which fell in Calabria, in 1817,[1] contained chromium. The red rain that fell at Blankenberg, in Flanders,[2] in 1819, owed its colour to the presence of cobalt chloride.

In 1872 three papers were published in the *Comptes rendus*,[3] on the origin of polar auroræ, which called forth one from Baumhauer,[4] where he refers to a theory as to their origin propounded in his thesis *De ortu lapidum meteoricorum* (Utrecht, 1844). After having shown the connexion which apparently exists between the planets,

[1] L. Sementini. *Atti della Reale Acad. delle Scienze*, 1819, i. 285. *Gilbert's Ann.*, lxiv. 327.

[2] Meyer and Van Stoop. *Gilbert's Ann.*, lxiv. 335.

[3] Le Maréchal Vaillant. *Compt. rend.*, lxxiv. 510 and 701.— J. Silbermann. *Compt. rend.*, lxxiv. 553, 638, 959, and 1182.—H. Tarry. *Compt rend.*, lxxiv. 549.

[4] E. H. Von Baumhauer. *Compt rend.*, lxxiv. 678.

their satellites, the comets, the shooting-stars, the meteorites (*"qui, pour moi, sont de petites planètes"*), and the zodiacal light, a disk of asteroids or cosmical matter massed together near the sun, he gives expression to the following views respecting the polar auroræ: Not only solid masses, large and small, but clouds of "uncondensed" matter probably enter our atmosphere (probabile etiam est nebulas materiei primigeniæ sine nucleo condensato in atmosphæram venire). If, from our knowledge of the chemical composition of the stones and irons which fall to the earth's surface, we may draw any conclusion respecting the chemical constitution of these clouds of matter, it appears possible that, as many of these stones consist partly, and the irons almost entirely, of iron and nickel, the attenuated cloud-like matter may also contain a considerable proportion of these magnetic metals.

Let such a cloud, the greater part of the constituents of which have magnetic characters, approach our earth, which we have been taught to regard as a great magnet. It will evidently be attracted towards the poles of this magnet, and, penetrating our atmosphere, the particles which have not been oxidized and are in a state of extremely fine division will, by their oxidation, generate light and heat, the result being the phenomenon which we term a polar aurora. Observations have shown that the seat of these phenomena is about, not the geographical, but the magnetic poles. Not a few facts, even at that time, could be advanced in support of the theory, which assumes the occasional presence of metallic particles in the higher regions of our atmosphere. More than once such particles had been discovered in a fall of hail. Eversmann[1] found in the hailstones which fell on the 11th June, 1825, at Sterlitamak, 200 wersts from Orenburg, Siberia, crystals of a compound of iron and sulphur, in which Hermann found 90 per cent. of that metal.[2] In hail which fell in the province of Majo in Spain on the 21st June, 1821, Pictet[3] found metallic nuclei which were proved to be iron; and the hail which fell in Padua on the 26th August, 1834, was observed to contain nuclei of an ashy grey colour. The larger ones were shown by Cozari[4] to be attracted by the magnet, and to contain iron and nickel. "It would," wrote Baumhauer, "be very interesting, in verification of this theory of the origin of polar auroræ, to detect in the soil of polar areas the presence of nickel." This theory, which at the time it was promulgated appeared so rash that it met with severe criticism by the great Berzelius,[5] has gained support from recent researches; among others, the discovery by Heis of the simultaneity of boreal

[1] E. Von Eversmann. *Archiv für die gesammte Naturlehre*, iv. 196.—A. Neljubin. *Archiv für die gesammte Naturlehre*, x. 378.—Hermann, *Gilbert's Ann.*, lxxvi. 340.

[2] Though von Baumhauer cites this instance, it does not appear that the metallic character of the "crystals" was fully established in this case. Neljubin found them to consist of 70 per cent. iron oxide, and 17·5 per cent. of other metallic oxides. In fact, this substance appears to have been an impure limonite, like that which fell at Iwan, in Hungary, on the 10th of August, 1841, and was probably not meteoric.

[3] Pictet. *Gilbert's Ann.*, lxxii. 436.

[4] D. L. Cozari. *Ann. Sc. Regn. Lomb.*, 1834, Nov. e Dec. *New Ed. Phil. Jour.*, xxxvii. 83.

[5] *Jahresbericht*, xxvi. (1847), 386.

and austral auroræ, the relation between the auroræ and the meteor showers, the perturbations of the telegraph lines, which not only accompany, but forecast an auroral display; and the identity of the light, principally that of the green portion of the spectrum, in zodiacal and auroral light, as established by Respighi.[1]

In connexion with this subject, reference should be made to the discovery by Reichenbach some years since of the presence of nickel in soils. From the Lahisberg in Austria, a conical hill some 300 to 400 metres in height, and covered to the summit with beech-trees, he took samples of soil from the thick underwood, and found therein traces of nickel and cobalt. Other specimens from the Haindelberg, Kallenberg, and Dreymarcksteinberg, adjacent hills, yielded the same results, and that from the Marchfeld plain also revealed traces of nickel. These hills consist of beds of sandstone and chalk, and are quite free from metallic veins. It has already been suggested that impoverished soils may have their fertilizing powers renewed by the precipitation of cosmical matter containing phosphorus.

1871. February 4th. 2·20 p.m. Konisha, Minnesota.[2]

The meteor appeared to come from N. of E. When it reached a point 4° N. of W. of Konisha (Lat. 45° 10′; Long. 94° 10′), and was at an elevation of 38°, it exploded with a detonation like the combined roar of a park of artillery. The concussion was so great that it shook the houses. From four different points on a base-line of 42 miles observers were not able to mark any divergence from the general direction of N. 86° W. The distance from Konisha must have been considerable at which the explosion of the meteor took place. No meteorites have yet been found.

1871. May 21st. 8·15 a.m. Searsmont, Maine.[3]

The explosion attending this fall resembled the report of a heavy gun, followed by a rushing sound like the escape of steam from a boiler. It probably came from the south, as the report was heard at Warren, 12 miles to the S.W., but not at Searsmont, 3 miles to the N.E. About two minutes after the explosion a woman saw the earth thrown up at a spot about 30 rods distant from her. The meteorite entered the hard soil to a depth of two feet, making a vertical hole, and striking some large pebbles which shattered the stone. It weighed altogether 12lbs., the largest fragment being 2lbs. When dug out, 25 minutes after the fall, it was still hot. The form of the complete stone is described as of an oval subconical figure, with a flat base, and resembles the Durala meteorite (1815, February 18th) preserved in the British Museum. The crust of the base is perfectly black, and more perfectly fused than that of the sides; it is moreover of unusual thickness, amounting to about

[1] Respighi. *Compt. rend.*, lxxiv. 514.—The green ray is that known as 1241 in Kirchhoff's scale; and near it is another of less brilliancy, 1826 in the same scale.

[2] *Amer. Jour. Sc.*, 1871. i. 308.

[3] C. U. Shepard. *Amer. Jour. Sc.* [3], ii. 133.—J. L. Smith. *Amer. Jour. Sc.* [3], ii. 200.

1–16th of an inch. The colour of the interior is a bluish-white and is very uniform. More than half the stone is made up of rounded grains of the size of mustard-seed, with fine-grained white or greyish-white interstitial matter, which Shepard calls chladnite, but which would perhaps now be more correctly termed enstatite. The rounded globules are bluish-grey, rarely with a faint tinge of yellow, are vitreous and translucent, have two imperfect oblique cleavages, and bear a resemblance to boltonite. Minute grains of iron are thickly scattered through the mass, with a few grains of troilite and one little black mass, which was probably graphite. The specific gravity of the stone is 3·626—3·701. Dr. Lawrence Smith traces a great resemblance, as regards the crust, between this stone and that which fell at Mauerkirchen (1768, November 20th); but both observers agree that in other respects, more especially in spherular structure, it is like the meteorite of Aussun (1858, December 9th). It is to be regretted that the constituents of this stone, which can apparently be so readily isolated, have not been subjected to separate analysis.

The total composition of the stone is as follows:—

Olivine	43·04
Bronzite, hornblende, with a little albite (or orthoclase) and chromite	39·27
Nickel-iron	14·63
Magnetic pyrites (?)	3·06
	100·00

The nickel-iron consists of:

Iron = 90·02; Nickel = 9·05; Cobalt = 0·43 = 99·5

and the stony portions, soluble and insoluble in acid (and alkali), amounting respectively to 52·3 per cent. and 47·7 per cent., have the following composition:

	SiO_2	Al_2O_3	FeO	MgO	Alkalies	Fe_7S_8		
A. *Soluble*	40·61	...	19·21	36·34	...	3·06	=	99·22
B. *Insoluble*	56·25	2·01	13·02	24·14	2·10	...	=	97·52

(To be continued in our next Number.)

III.—On the Subdivisions of the Triassic Rocks, between the Coast of West Somerset and the South Coast of Devon.

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

Geological Survey of England and Wales.

Much has been written on the relations of the Devonshire Trias as observed in the south-coast section. The subject itself is associated with many names of high scientific repute, so that, were the following epitome the result of partial examination, or in any way aided by preconceived notions arrived at from the perusal of the labours of those who have gone before, I should not feel justified in differing in many points from men infinitely my superiors in general geological information. But after a careful survey of these rocks, extending over three years, beginning in the Vale of Taunton, without any previous acquaintance with the series, and working from dark to light, my views altering as to their mode of occurrence, as I proceeded southwards, till the same divisions were established at Tiverton in the summer of 1872, as are displayed, with local variations, in the south coast. A rough examination of the latter in the spring of 1873, in company with my friend and colleague, Mr. H. B. Woodward, fully substantiated the lithological divisions I had been enabled to make inland, and showed us the true nature of several members, the absence of which had been accounted for by local impersistency or gradual and even abrupt transition. The additional light thrown upon the subject by the South Devon coast, showed the presence of numerous faults, cutting out, and displacing the divisions, which, aided by a practical acquaintance with most of the lithological variations the beds assume, enabled me to account for many enigmatical districts in my former work, to trace many faults with comparative certainty, and led to the persumption, that in a few local instances, between Watchet and the South Coast of Devon, in which the lowest division is either altogether unrepresented, or very feebly so, its absence may be accounted for by the overlap of the overlying member, or by its total or partial elimination by faults. In the spring of 1874, the establishment of the same general sequence, as exposed on the south coast, in the Watchet district, by Mr. Woodward and myself, and the consequent corroboration of my views by him, has enabled me to state the results arrived at, with much less diffidence than my own unsupported testimony would allow. For the publication of this resumé, in anticipation of the Survey Memoir on the district, in which all details will be given, I am indebted to the kindness and consideration of the Director of the Geological Survey of England and Wales.

As we cannot go into details at present, the subjoined table of the divisions made, and a brief allusion therein to the more important lithological varieties they assume, supplemented by a very short account of each division, will be sufficient to set forth the skeleton of our facts. The beds are given in descending order.

1.—Red Variegated Marls, calcareous above, loamy in lower beds, locally containing veins of gypsum.[1]

2.—Red, buff, grey sandstones and rock-sand, containing calcareous nodules, and thin impersistent bands and pockets of dark red clay. Lenticular masses of sandy marl and beds of the same were locally shown near their junction with the overlying marls. In some localities the sandstones become very calcareous; in others they are mottled.

3.—Pebble beds of the Devon Coast, large ellipsoidal pebbles of quartzite with impersistent beds of sand, in a matrix of red sand. Pebble beds of Burlescombe, pebbles mostly small and round, of quartz and grit, the former predominating. Conglomerate, containing pebbles and subangular fragments of limestone, grit, and quartz, of various sizes, in sandstone matrix, generally thick-bedded.

[1] Since this paper was sent to press, Mr. P. O. Hutchinson, of Sidmouth, informed me that the occurrence of pseudomorphous crystals of rock-salt had been noticed by Mr. Ormerod and himself in the Upper Marls, near Salcombe Mouth; I have since obtained a few specimens from that locality, and also, in descending the cliffs at Wind Gap, between High Peak and Peak Hills, west of Sidmouth, was very fortunate in obtaining numerous slabs exhibiting well-marked pseudomorphs and ripple-markings.

4.—Red Variegated Marls, slightly calcareous, loamy in the lower portion, and containing impersistent beds of sandstone near the base.

5.—Red sandstones and beds of rock-sand, locally brecciated. Breccia, angular fragments of grit and quartz, in rock-sand. Breccia, hard and thick bedded, fragments of locally derived rocks. Breccia, gravelly, large grit pebbles in sand, with intercalated beds of rock-sand. Breccio-conglomerate, pebbles and subangular fragments of grit, quartz, and locally limestone. Breccia of shale fragments in red loam and loamy clay. Dark red clay, mottled grey, of very local occurrence.

1.—*The Upper Marls.*

The above name is applicable to these beds, between Watchet and the south coast of Devon, only near the line of outcrop of the underlying sandstones, as in the large tract of country in Somersetshire, north and south of Taunton, over which the Trias is exclusively represented by Marls, it is very doubtful whether the west Somerset and Devon divisions underlie them. On the coasts of Devon and West Somerset, the Marls are in places intersected with gypseous veins; but in the intervening country they are not observable, probably owing to the absence of extensive sections.

The lower beds are loamy, sometimes almost passing into rock-sand. Near Sampford Arundel (near Wellington), and at Sidmouth, a bed or two of sandstone is observable, showing a transition to the underlying sandstones.

2.—*The Upper Sandstones.*

So called here to distinguish them from the sandstones of No. 5 (the lowest division). On the coast of Devon they consist of red sandstones, with pockets of red clay occasionally, and corrugated calcareous nodular bands. About 50 feet from their base are found the celebrated conglomeratic beds of Otterton Point, memorable as the locality where Mr. Whitaker's *Hyperodapedon* was discovered.

This division is persistent over the whole area, with one exception, south of Watchet, where it is faulted out, showing itself however in one or two places along the line of fault.

Inland, the Upper Sandstones exhibit great variety of colour and composition. In some places they resemble greensand, and have even been mistaken for it on Woodberry Common, north of Exmouth. Between Bishop's Lydeard and Crowcombe Heathfield, south of Watchet, the sandstones are exceedingly calcareous, and contain uneven beds of bluish rock, resembling a marlstone; these have been carefully observed by my colleague, Mr. J. H. Blake. The calcareous sandstones of this district are burnt for lime. The Otterton Point beds prepare us for the next and underlying member, the Pebble beds and Conglomerate.

3.—*The Pebble Beds and Conglomerates.*

This division is the thinnest in the series, seldom exceeding 100 feet in the Conglomerates, and 60 feet in the Pebble beds; consequently it is much affected by faults, which obscure the relations of the varieties composing it to each other, and to which, in almost every instance, in the district under consideration, its local absence is due. The feature made by the Pebble beds, noticed by Mr. Pengelly, maintains over the whole area, marking the line of faults where the division is unrepresented at the surface. Between Whimple and Ottery St. Mary the large quartzite pebbles give place to smaller ones of quartz and grit; the beds, as at Uffculm, are sometimes compacted, sometimes gravelly, as at Burlescombe. At White Ball Hill tunnel the Pebble beds give place to Conglomerates, containing large limestone pebbles, besides those of grit and quartz. The beds are generally massive. Both Pebble beds and Conglomerates contain impersistent beds of sand and sandstone, and in some instances are partially replaced by them.

4.—*The Lower Marls.*

The division underlying the Pebble beds and Conglomerates, I have called Lower Marls, to distinguish it from the Upper Marls. It consists of red marls, variegated greenish-grey, much faulted in the lower beds on the coast of Devon, between Exmouth and Budleigh Salterton, where it contains beds of sandstone. North of Exeter its true nature is very generally concealed by a thick loamy clay soil, and as the beds of sandstone are not traceable, they may be absent, or indicate a passage to the underlying series, only in places where its upper variety consists of sandstones.

5. *The Lower Sandstones and Breccias.*

This is the most variable member of the group, and as a description of all its phases with which I am already acquainted would occupy more space than is allotted to the whole of this brief notice, we will only glance at a few of the salient points.

At Exmouth, as the junction between this division and the Lower Marls is a faulted one, I am forced to concede the entire absence of sandstones, which are developed at Topstham, to that cause, so that between the coast of Devon and Burlescombe the upper variety of this division consists of sandstones; but, from Burlescombe to Williton they seem to occur generally at the base of the series. Beds of sand and sandstone, intercalated with the breccias, occur at any horizon in the lowest division. They consist of red rock-sands and sandstones; variegated near Torquay; are sometimes stained blackish; seldom very calcareous, and only locally contain calcareous nodules.

Similar varieties of Breccia occur at different horizons in the division, in different places: For instance, the hard Breccias of Teignmouth, and those of Heavitree and Sampford Peverell (east of Tiverton), contain subangular, angular, and occasionally a few pebble fragments of grit and quartz, with limestone in the first and last instances, and igneous rocks in the first and second. The breccias of Dawlish and Exmouth present the appearance of hard red rock-sand, from which the stones, which are generally small, are weathered in relief, by their superior hardness; allied breccias occur near Stogumber and at Minehead; and with modifications, here and there, between Minehead and Dawlish; the fragments in this variety are generally of grit.

Breccias of shale fragments in sand matrix are a kind of modification of the Dawlish variety, and occur in the Crediton and Tiverton valleys, and near Stogumber.

Brecciated loam, with seams of red clay, occurs in Exeter, where it furnishes material for brickmaking; the shale fragments, being very small, are burnt in the brick and do not militate against its utility. This variety is largely developed in the Crediton valley, it is generally associated in its very local instances of occurrence with dark red clay, which appears either to replace it or to occur intercalated, as in, and near Exeter, and in the Crediton valley. Beds of hard red sandstone occur in the brecciated loam of Exeter.

Some varieties of the Breccia series so much resemble the gravels resting on the older rocks and frequently obscuring their junction with the Breccia, that, in the absence of good sections, they are hardly distinguishable from them. These contain rounded subangular and angular stones of grit and quartz, with intercalated beds of rock sand, as at Bradninch; or are chiefly composed of angular fragments and also contain pieces of shale, as on the north side of the Tiverton valley. Breccio-conglomerates occur between Bathealton (south of Wiveliscombe) and Williton; they contain pebbles, subangular and angular fragments of grit, quartz, and, very occasionally, limestone, in a rather coarse sandstone matrix; the beds of Sampford Peverell and Halberton form a kind of connecting link between the breccio-conglomerates and the hard Breccias of Heavitree (near Exeter) and Teignmouth.

The lowest division occupies a considerable area between Tiverton, Exeter, Crediton and the south coast: west of Collumpton, it is almost entirely composed of sandstone, but the presence of two or three small patches of breccia seems to indicate the concealment of the lower beds, possibly by overlap. Between Collumpton and Grinham Bridge (south-west of Thorn St. Margarets), the lower division is feebly represented, and, in places, either represented by clay undistinguishable from the overlying marls, overlapped by them, or faulted out. At Canon Leigh (near West Leigh limestone quarries), a few beds of lower sandstone are shown faulted against the older rock, as also at Horridge Down, in the railway cutting, south of Wiveliscombe. Between Thorn St. Margarets and Wiveliscombe, this division is much affected by faults, and nowhere fully represented; between Wiveliscombe and Williton, it is well shown, and exhibits many phases; between Williton, Minehead and Porlock it is frequently faulted out, but occurs about Luckham (near Porlock) and at Minehead.

Disturbances.

The red beds of South Devon and West Somerset are so much affected by faults that dips in any of the divisions must be taken with extreme caution; and as small faults affecting single homogeneous members would not be nearly so readily recognized as those affecting different divisions, most estimates of thickness based on breadth of outcrop must necessarily be conjectural. A large east and west fault, between Wiveliscombe and Bishops Lydeard, throws all the beds north of it, further east; so that Sandstones and Breccias of the lowest division are faulted against Upper Sandstones; Lower Marls entirely eliminated; Conglomerates and Upper Sandstones faulted against Upper Marls. The frequency of these disturbances renders estimates of the thicknesses of the beds, even in the Coast Section, extremely conjectural.

Thickness.

In taking estimates from the Coast Section, the fault at Seaton; synclinal structure at Beer; fault at Chit Rock, throwing down Upper Marls, West of Sidmouth; faults near Lardrum Bay repeating bottom beds of Upper Marls; numerous faults affecting Lower Marls and Lower Sandstones, between Straight Point and Exmouth,[1] and the elimination of a part of the lowest division at the latter place; faults in the breccia between Dawlish and Torquay; and a considerable allowance for the fact that the coast-line, between Exmouth and Torquay, is diagonally across the dip, and therefore does not show the breadth of outcrop; must be taken into account. We have not yet finished the re-survey of these rocks, so that our estimates of their thickness, particularly of that of the Lower Marls and underlying beds, must be taken as problematical, not, however, erring on the side of parsimony. There is no apparent foundation for the miles of thickness that have been ascribed to them, and Sir H. de la Beche seems to have formed a shrewd estimate, which, though possibly under the mark, is some miles nearer than the more liberal calculations. Judging from what we have seen, Mr. Woodward agrees with me in considering that the following estimates do not err on the side of limitation.

1. Upper Marls (of Coast Section)	1,000	feet.
2. Upper Sandstones	460	,,
3. Conglomerates and Pebble-beds	80	,,
4. Lower Marls	460	,,
5. Lower Sandstones and Breccias	1,000	,,
	3,000	,,

IV.—The Sediment Theory of Drift.

By J. R. Dakyns, M.A.,
Of the Geological Survey of England and Wales.

The publication in the Number of the Geological Magazine for November, 1874, of Mr. Goodchild's ingenious Drift theory leads me to make a few remarks on the subject.

[1] Since the above was written, Mr. P. O. Hutchinson, of Sidmouth, kindly furnished me with a sketch section of the railway cutting between Langsant Point and Dawlish, made during a visit to the latter place, and showing, besides numerous small faults, one of considerable importance, on the west side of Langsant Point; as the Breccia occurring at that Point and in the plantation at Exmouth is almost exactly similar to that exposed in the cliffs, by the beach, on the west of Dawlish, and the beds in the railway cutting chiefly consist of sands, the probability of these latter being representatives of a part of the sandstones of the division No. 5, cut out by the fault at Exmouth, immediately struck me. Future investigation will probably supply the solution, which, if my inference be correct, would lead to a further reduction in the estimation of the thickness of division No. 5.

To my mind one of the great difficulties connected with the Drift has always been to account for the uniform distribution of Till along the bottom and flanks of valleys. A terminal moraine thrown down at the stationary end of a glacier, or lateral moraines similarly dropped along the flanks of the melting ice, or a heap of bottom or ground moraine shoved forward by the snout of an advancing glacier or the edge of an advancing ice-sheet, and there left on the retreat of the ice, or deposited in sheltered spots under the lee of hills or bosses of rock,—these phenomena were intelligible: but how a uniform sheet of Till should be left along a smooth valley or on open ground was not intelligible on any land-ice theory. Geologists but conjured with the term "moraine profonde." The ice that scored and polished the solid rock could not at the same time be moving over a cushion of Boulder-clay. It must have been in contact with the rock: it might accumulate the waste of the polished rocks as Till in isolated sheltered spots; but not uniformly over the face of the country, and least of all where the underlying rock shows signs of glaciation; in fact, the mere existence of Till itself negatived the idea. Yet such was the manner of Drift distribution. Anxiously I have scanned the edges of the Norwegian ice-fields for a solution of the difficulty, but in vain. Mr. Goodchild's theory of the deposition of the Till, as a sediment melted out of the ice in place, seems to me to remove all difficulty on the subject. But the difficulty of understanding how the ice got the stones with which it was charged, where the country was so buried in ice that no rocks remained sticking out to afford detritus by their waste under frost, remains the same. I have myself suggested[1] an explanation; but at first sight there seems to be a contradiction between the smoothed surfaces of ice-worn rocks, so difficult for the weather to take hold of, and the idea of frost disintegration sub-glacially.

Some phenomena, too, of Drift distribution cannot be explained on the Sediment theory. Such a theory will not account for the presence of Drift on one side of a valley rather than on the other, nor for the accumulations of Drift specially in the angle between two valleys at their junction. These phenomena, on the other hand, can be fairly accounted for on the supposition of the Drift material having been dropped by the moving ice, and left in sheltered places.

While, however, the sediment theory accounts very well for the uniform spread of Till, I cannot understand how well-washed current-bedded sands and gravels are to be explained on this theory. Nay more, even granting that they may be so explained in some cases, there is still no explanation of such a general phenomenon as *the order* of the Lancashire Drift, consisting of two beds of Till, with an intermediate set of washed sands. Why should the sediment melted out of the ice occur in this fixed order? Such a sequence bespeaks a sequence of conditions *in time.* On the Sediment theory there should be no other arrangement than a horizontal one, whereby the sediment should be found to be more rounded, and with more frequent

[1] GEOLOGICAL MAGAZINE, Vol. X. No. 2, February, 1873.

intercalations of laminated beds, the further we go from the central fells. The general mass should change in character horizontally; but should not offer any such fixed and neat sequence as Lower Till, Middle Sands, Upper Till. Again, Mr. Goodchild would explain the Middle Sands and Eskers in the same way, as results of one and the same cause. Whence then their difference? Eskers are specially distinguished by their[1] arched bedding, their included hollows, and the "ghosts of scratches" on the pebbles. If due to the same cause, why are they so markedly different from the flat spread of the Middle Sands with its false bedding of the ordinary character? Their difference of *form* bespeaks a difference of *formation.* Nor do I see that they offer any insurmountable difficulty. I used once to be much puzzled by them; but the idea of conflicting currents, which I got from Mr. Fox Strangways, seems to clear up the mystery of the land-locked hollows, etc. Does any one suppose that, were the North Sea bottom laid bare, we should not find regular Esker mounds in the sand-banks, whose existence causes such unpleasant sensations to the Norwegian voyager?

The very general prevalence of Esker and other sands and gravels up to the height of 700 or 800 feet above the sea-level is itself an argument in favour of a submergence of the land to that amount: and this idea is immensely confirmed by the proofs in Norway of a like amount of recent submergence, afforded by horizontal terraces of sand, the remains of old deltas and beach-marks along the solid rock over the sea, to say nothing of the shells. Moreover, if I mistake not, the grooves on the top of Bar Fell in Yorkshire are themselves evidence of submergence at least to the extent of 2200 feet. The reason is this: the North and West Ridings of Yorkshire were, like other mountain groups, to wit, Norway, Scotland, the Lake Mountains, and Iar-Connaught, glaciated radially: that is, the ice flowed outward from the central fells in all directions, much in the same way as the rivers do now: the snow and ice drainage was broadly analogous to the water drainage.

The great dales, Wensleydale, Wharfedale, Nitherdale, Ribblesdale, Dent, contain no foreigners in the Drift: the Drift material is, as far as I know, entirely composed of rocks from the basins of the separate dales. There is thus no evidence of any far-derived ice, whether an ice-cap moving from the pole or an ice-sheet from a distant mountain group. All the evidence is in favour of home-made ice.

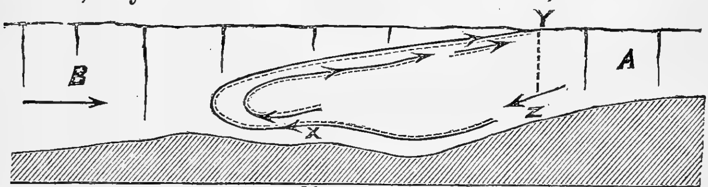
The general centre whence the ice moved outward may roughly be placed about Bar Fell. Now at the radiant centre, where the motion is merely nascent, there can be no grooving, both because the motion is practically nil and because the ice has had no time nor space wherein to gather its grooving tools. As well expect to find denudation of rocks going on in the peaty marsh, whence issue the rivers Wharfe and Ribble, where the flow of the water is so feeble that it is hard to say which way it will go, as to find scratches under the ice at its starting-point. Yet Bar Fell is grooved on its summit.

[1] See my section of gravel-pits near York, in the Quarterly Journal of the Geol. Society for November, 1872.

We have already shown that there is no evidence of continental ice from afar. Must we not then conclude that the grooves were caused by floating ice continually scraping along the submerged land?

About the transport of erratics I will not speak, as I have no evidence to offer on the subject: but this much I must say, that if it is the general rule for moving ice to carry unbroken such fragile substances as shells or glass bottles, the vast number of rounded stones in the Drift is more inexplicable than ever.

The question too of counter currents in the ice I leave to those who are better acquainted than I am with the physics of ice. But if I understand Mr. Goodchild aright, his idea involves the fallacy of perpetual motion: for in the figure below, the dotted arrows indicating the course in the ice of any boulder, say from X, current A sets outward (from the lake mountains suppose) carrying boulders from the centre of the district up to the point where it meets with B (a current from Scotland suppose), and is turned back again at a higher level. Boulders of X are worked up to Y: then when the ice melts, they are melted out as a kind of sediment, and left at Z.



X

This, I conceive, is how Mr. Goodchild would explain the fact that "even in those parts of the Lake District in which the majority of the boulders have moved outwards at low levels, we find that some of the very same rock has been transported in opposite directions towards the heart of the mountains," to wit, "by the strong upper currents which were setting in from Scotland." So far so good. But in the case figured, boulder X arrives at Y so late that the ice is then on the point of melting away entirely, and it quietly subsides to Z. But what of a similar boulder which sets out earlier on its travels, and reaches the point Y, say, at the height of the Glacial Period?—what becomes of it? It must go somewhere. It must surely get again into the outward current A, and be carried back nearly in its old course, and so go on revolving as long as the ice lasts. There is no escaping this impossible conclusion, unless we suppose either that the Scotch ice B went clean over the Lake mountains on the top of their native ice, or that the conflicting currents flowed away right or left laterally to the low ground. There is not a particle of evidence to show that the Scotch ice went over the Lake mountains. If then the conflicting currents flowed away laterally, why should there be any over-riding at all? On meeting, the stronger current would dam back the weaker one till a position of equilibrium was attained; and thenceforth the two currents would flow away literally in a united stream according to the fall of the ground.

Postscript.—On referring to Mr. James Geikie's "Note on the Occurrence of Erratics," I see that Forbes thought there was evidence in the Swiss glaciers of stones being "actually introduced into the ice by friction at the bottom of the glacier." Of course, if there is positive evidence in Switzerland of this sort of thing, the presence of stones in the Till ceases to be a difficulty.

V.—Note on Mr. Goodchild's Theory of the Sub-glacial Formation of Gravels, etc.

By Edward T. Hardman, F.C.S., etc.;
Of the Geological Survey of Ireland.

In the paper on "Drift" in the Geological Magazine for November, 1874,[1] Mr. Goodchild, in proposing his new theory, appears to invite discussion on it. I therefore beg to contribute my *quota* towards upholding the marine, as against the exclusively glacial, deposition of certain gravels belonging to the Drift.

According to the last paragraph of his paper,[2] this theory is, that all the glacial deposits were formed under ice, and with the assistance of sub-glacial streams; and that neither stratification nor the presence of marine remains proves the former agency of the sea in their formation.

Whether this idea will meet with general acceptance I shall leave to others to determine, on the various merits. It is certainly ingenious, and would no doubt serve to explain the presence of lenticular patches of sand, gravel, and laminated clays, such as are frequently found in the Boulder-clay; but its application in the case of the masses of sand and gravel that are often spread out over large tracts of country appears to be hardly tenable. I shall, however, confine myself to a point which I noticed in connexion with the Drift of the North of Ireland during my work for the Geological Survey, and which seems to me to have a legitimate bearing on the question. Besides bringing forward a new link in the chain of evidence, it refers to a matter not likely to be observed in any other district.

As every one is aware, one of the chief features in the geology of the North of Ireland is the existence of the Upper Chalk with Flints, covered by a very thick sheet of Basalt, the two formations being in effect co-extensive; for there is hardly any part of the area occupied by the Chalk which has not its protecting cap of Basalt.

The Drift, for the purposes of this note, may be divided lithologically into Till,[3] and stratified sands and gravels with brick-clays, in some of which fragments of shells have been found. Now the contents of these Drifts differ very widely. The "Till" contains invariably a very large per-centage of the local rock, whatever it may happen to be—Limestone when that rock prevails; Sandstone and shale near Coal-measure ground; and a plentiful supply of Basalt, both in large blocks and small pebbles, when over or within reasonable reach of it, together with igneous and metamorphic rocks

[1] On Drift, by J. G. Goodchild, F.G.S. [2] *Loc. cit.* p. 510.

[3] In a few places patches of Boulder-clay (Upper Boulder-clay) resting on the sands and gravels occur in the district with which I am acquainted.

from some distance; but in no case Chalk or Chalk-flints to the amount of more than about three or four per cent., even when in the Chalk country, unless where in very close proximity to unprotected Chalk exposures.

On the other hand, the gravels, as a rule, contain perceptibly less of the local rock, plenty of travelled or foreign pebbles, and a great abundance of chalk and flints; of the last two so much that the ground is often white with them; and this often when at a distance of 100 feet from, or sometimes underlying them, is Boulder-clay, on which a considerable amount of time and trouble should be expended before anything from the Chalk would turn up.

The district to which I refer is that comprising the south of Derry and Antrim, great part of Tyrone, and the northern part of Armagh. In those places, I have examined a great number of exposures in "Till," together with equally many gravel-pits, and always found the distinction noticed above to obtain.

Portlock[1] gives a list of gravel-pits in the counties Derry, Tyrone, Armagh, and Fermanagh, noticing those of 52 parishes, the gravel of 35 of which contained chalk or flints; and in 25 of these chalk is *not* the local rock. They comprise from two to three exposures per parish on an average. I mention this to show how general the occurrence of chalk is in the gravel of this large district.

Now if all the Drift of these parts had been deposited first by ice, and almost simultaneously re-arranged in places by glacial river-action, should we not expect to find in the re-arranged part the same constituents as in the so-called Till? or, to put it more clearly, must not all the pebbles of the gravels have previously existed in the moraine matter of the glacier, and would they not, therefore, be found in all parts of the Drift in nearly the same relative proportions? According to the hypothesis, the gravels would be merely the Boulder-clay minus the clay, and I see no reason why the *chalk débris* should become concentrated by washing. Were the proportion of chalk, etc., in the "Till" very variable, it might indeed be supposed that these gravels had their origin in some such chalky Drift. But this is not consistent with the facts. The "Till" is, as I have mentioned, remarkably free from such pebbles, and in the extensive district I have examined hardly any difference in this respect could be observed.

This difference may be easily accounted for on the usual theory of the glacial formation of the "Till," or Boulder-clay, and the later marine deposition of these gravels. The glaciers, or ice-sheet, which gave rise to the former had, in order to reach the chalk, to work through the hard basalt overlying it, and this attempt was in but few instances successful, as will be at once seen on looking at the geological map. Beyond the basaltic sheet the ice passed over schists and other metamorphic rocks, Old Red Sandstone, Carboniferous Limestone, and the older Mesozoic strata.[2] While, therefore,

[1] Geological Report on Londonderry, etc., pp. 747–8.

[2] There is evidence that the general Physical Geology of this district just before the Glacial Epoch was not very different from that which prevails there at the present day. This I have given in a paper read at the late meeting of the British Association at Belfast, "On the Age and Mode of Formation of Lough Neagh."

we find all the last-mentioned rocks in great plenty in the Till, together with basalt, thanks to this last we get little or no chalk, or flints; for even in the rare cases where the chalk was cut down to, or was already exposed, the proportion of chalk to other rocks would be very insignificant.

Now let the land be submerged, and the sea come into play around the chalk escarpments. It would soon form cliffs, and not content with that, would undercut, and eat into the comparatively easy-worn and well-jointed chalk, as it is now doing all along the northern coast, tearing out large blocks, rounding them, and wearing them into pebbles. The overhanging basalt would soon be brought low, and the result would be a gravel composed largely of basalt, chalk, and flints, together with such pebbles as might happen to lie in the Drift—if there were any—previously deposited, overlying the cliffs, and perhaps some others drifted round from distant parts of the then coast. There can be no difficulty on this point, for as the chalk is found at all heights from the present level of the sea up to 1400 or 1500 feet, any amount of submergence between these limits would bring it under the influence of the sea. Such a gravel, then, being swept away over the sea-bottom, would cover the former Drift; if then the ground emerged at any given point of this area, the "Till" or Boulder-clay would be found to contain most local rocks, and but little chalk; while the gravel would contain few local rocks, but a great amount of chalk and basalt.

I find, on referring to Portlock's exhaustive Report, that he had somewhat the same idea as to the formation of the shelly clays of the northern part of county Derry, namely, that they were formed in a sea which cut away the chalk and basaltic cliffs, hence the occurrence in them of so many chalk and basalt pebbles.[1] There can be little doubt that these clays belong to the Drift, although Portlock considered them to lie beneath it: for not only are similar clay-beds found everywhere in the gravels of the district, but these particular beds contain the characteristic shell of the Clyde beds, *Nucula oblonga,* as well as the usual drift shells, *Cyprina Islandica, Turritella terebra,* and *Astarte multicostata* (?).

With relation to these beds the following point occurs. Portlock mentions, and remarks on the fact, of "the delicate *Nucula* being uninjured, as if deposited on the spot, while the strong *Cyprina* has been almost destroyed." If then all these beds had been brought into their present position, from 100 to 450 feet above sea-level, by moving ice, why should one genus be shattered, and the other preserved? They should have all been either preserved without distinction, or broken up indiscriminately.

The chalk and flints to which this note refers are not only found in the gravels of the North of Ireland, but also—more sparingly—in the midland and southern counties. I have noticed them in the gravels of county Meath frequently, also occasionally in those of counties Carlow[2] and Kilkenny, but more rarely. Still, however, the

[1] *Op. cit.* p. 737.

[2] In the gravels of Carlow I have found shell fragments; in one near the town, I

distinction noticed in the north holds good—comparative abundance in the Gravels, and greater rarity in the Boulder-clay. It appears as well that they have been seen in the gravels of Wexford and of Cork.[1]

It must be borne in mind that the Irish Chalk is of a very hard texture, almost as hard as ordinary Limestone, and much harder than the Coal-measure Shales, Bunter Sandstone, and Keuper Marls, all of which occur so plentifully in the "Till" of the northern district; so that its absence cannot be ascribed to crushing and pulverization by the ice-sheet, nor can it be laid to the score of solution by water containing carbonic acid, for this would also affect the Limestone. Besides, neither of these suppositions would account for the scarcity of Chalk-flints.

VI.—On Some of the Massive Forms of Chætetes, from the Lower Silurian.

By H. Alleyne Nicholson, M.D., D.Sc., F.R.S.E.,
Professor of Biology in the College of Physical Science, Newcastle-on-Tyne.

Chætetes petropolitanus, Pander.

The typical forms of *Chætetes petropolitanus*, Pander, are free in habit, and are invariably furnished with a flattened or concave base, which is covered with a thin concentrically-wrinkled epitheca. The general shape of the corallum is typically a cone or hemisphere when full-grown, and a concavo-convex disc when young; but its adult form is liable to great variations; and even the young examples are not constant, being sometimes plano-convex, or slightly bi-convex. The calices are exclusively carried upon the upper surface of the mass, and are thin-walled, polygonal in shape, and destitute of intermediate tubuli. Very often the surface exhibits minute tubercles, carrying corallites of a slightly larger size than the average; but this phenomenon does not appear to be constant. Young examples may have a diameter at their base of four or five lines, and a height of three lines; adult specimens may have a long diameter of four inches or more at the base, and a height of an inch and a half; but the majority of individuals exhibit dimensions intermediate between these measurements.

Stenopora patula, Billings (Canadian Naturalist, vol. iv. p. 427), as hinted by Mr. Billings himself, is to be regarded as only a well-marked variety of *C. petropolitanus*. It agrees with the typical examples of the latter in its free habit, in its surface-characters, and in its possession of a concentrically-wrinkled epitheca. It is peculiar only in its shape, having the form of an approximately circular disc, the basal surface of which is flat, or slightly concave, and is covered by an epitheca; whilst the upper surface is

got two perfect shells. One a *Purpura lapillus*, the other a small bivalve which I have not been able to identify with certainty, but it appears to be *Tellina solidula*.

[1] On Re-arranged or Glacialoid Drift, by G. H. Kinahan, M.R.I.A., Geological Magazine, Decade II. Vol. I. No. 3, pp. 112 and 119.

usually elevated into a central boss, but is otherwise slightly convex. The largest example I have seen is about three inches and a half in diameter, and has a thickness of four lines near the margin, and of one inch in the centre; but Mr. Billings mentions examples which had a diameter of six inches.

There can be no hesitation in considering the above forms as the type of *C. petropolitanus*, and the only question is whether we are to consider a free habit and the possession of a base covered with a concentrically-wrinkled epitheca as essential characters of the species or not. This question is forced upon us by the existence of two other groups of forms which in many respects agree with *C. petropolitanus* as above described, but do not possess the two characters just alluded to. One of these groups, commonly represented in the Hudson River Group of Canada and in the Cincinnati Group of Ohio, comprises forms which have often been spoken of as "puff-ball varieties of *Stenopora fibrosa*." These forms occur as small, spherical, sub-spherical, nodulated, or irregular masses, which exhibit no indications of a concave base, or of an epitheca. The calices seem to cover the whole surface, and the base is indicated in fractured specimens by the radiation of the corallites from a point. Some specimens appear to have been attached to Crinoids, the column of which traverses their centre; but others exhibit no phenomena which would enable us to assert that they were attached to any foreign body. In their surface-characters these forms present nothing special; but so far as I have observed, they exhibit no tubercles, nor any groups of large-sized corallites.

The second group comprises small, hemispherical, obtusely conical, or sub-spherical masses, which are extremely like the typical forms of *C. petropolitanus*, but differ in having the flattened or concave base firmly attached to some foreign body, such as the shell of a Brachiopod, or the column of a Crinoid. The calices in well-preserved examples are thin-walled and polygonal, with minute intermediate tubuli, and distinct groups of large-sized corallites, but entirely without surface tubercles. These forms occur in abundance in portions of the Cincinnati Group of Ohio; and I should be disposed to regard them as a variety of *C. petropolitanus*. I do not, however, feel at all so certain about the affinities of the "puff-ball" forms, which are so common in parts of the Hudson River Group of Canada.

It may be noticed here that none of the forms here considered can be referred to *Chætetes*, as this genus is defined by Lonsdale and McCoy. They, none of them, can be proved to increase by fission, and, in all, a rough fracture exposes the walls of the corallites. Neither, again, can they properly be referred to *Stenopora*, as they exhibit none of the essential characters ascribed by Lonsdale to this genus. Those, therefore, who refuse to extend the limits of *Chætetes* as defined by Lonsdale, will be compelled to place all the above-described forms under *Monticulipora*, D'Orb.

CHÆTETES UNDULATUS, Nicholson.

What forms were included by Mr. Say under the name of *Favosites* *lycoperdon,* I have no means of judging, not having access to the original work. It is certain, however, that Prof. Hall (Pal. N.Y. vol. i. pls. xxiii. and xxiv.) included under the name of *Chætetes lycoperdon* several distinct forms, such as *C. petropolitanus,* Pander, *C. Fletcheri,* Edw. and H., and *C. delicatulus,* Nich. Under these circumstances, the name of *Chætetes lycoperdon* will have to be abandoned; unless, as is improbable, the original form described by Mr. Say can be clearly identified and shown to be distinct from previously recorded forms.

Amongst the forms included by Hall under the name of *Chætetes lycoperdon,* Say, there is, however, one (Pal. N. Y. vol. i. pl. xxiii. fig. 1*g*), which is far from uncommon in the Trenton Limestone and Hudson River Group of Canada, which appears to me to be so far distinct that it may be provisionally separated under the name of *C. undulatus.* This form is certainly very distinct from the typical forms of *C. petropolitanus,* Pander; since it never shows a concave base or concentrically-wrinkled epitheca, and appears to have been never free, but always fixed by its base. It forms great lobate masses, sometimes more or less funnel-shaped, and often undulated or deeply indented and folded laterally. None of my specimens have the surface well preserved; but so far as can be determined, the calices are polygonal, thin walled, about six or eight in the space of one line, destitute of minute intermediate tubuli, and showing no well-marked tubercles, nor groups of large-sized corallites. A rough fracture exposes the walls of the corallites, which radiate from the base, and are often arranged in successive layers or strata. Without insisting upon the specific distinctness of this form, it appears to me to be sufficiently well marked and common to deserve at any rate a provisional title.

REVIEWS.

Notes on Palæozoic Botany, extracted from Dana's Manual of Geology (Revised Edition). New York, 1874. (*Second notice.*[1])

WHATEVER may be the ultimate conclusion of Geologists in relation to *Eozoon Canadense* as the very oldest form of life met with on our Earth, it is certain that abundant remains of several orders of animals have been obtained from rocks older than those which have yielded any very good evidence of Plants.

MM. Torell, Linnarson, Nathorst, and other observers, have described various plant-like impressions in rocks of Cambrian age in Sweden,[2] and Dr. Henry Hicks, F.G.S., has described similar indications observed by him in the Lower Arenig Rocks of Ramsey Island, St. Davids.[3]

Prof. James Hall in America has also noticed impressions of seaweeds (*Buthotrephis*) in the Trenton series (Lower Silurian), whilst

[1] For previous notice see Geol. Mag., 1875, p. 44.
[2] Geol. Mag. 1869, Vol. VI. p. 393, Pl. 11, 12, and 13.
[3] Op. cit. Vol. VI. p. 534, Pl. 20.

indications of Fucoids[1] occur even still earlier in the Primordial rocks of Canada and the United States.

At this early period, however, animal life was already represented by at least four great sub-kingdoms of the Invertebrata, namely, Protozoa, Radiata, Mollusca, and Articulata.

Among plants Acrogens are first represented in the Uppermost Silurian near Ludlow, where fragmentary remains of seeds referred to the *Lycopodiaceæ,* and cortical markings have been discovered; whilst in the Upper Limstones of Gaspé, Canada (Upper Silurian), a small species of *Lycopodiaceæ,* described by Dr. Dawson under the name of *Psilophyton princeps,* occurs; and in the Ohio Limestone remains of a Tree-fern (*Caulopteris*) have been met with.

Prof. Dana mentions, as amongst the earliest types of terrestrial vegetation, a Yew, named by Dr. Dawson *Prototaxites Logani,* stems of which have been met with measuring three feet in diameter. (Dana, op. cit. p. 258.)

But in a paper by Mr. Carruthers, F.R.S.,[2] communicated to the Royal Microscopical Society of London, the author points out that the fossil in question had been described by Dr. Dawson *under two names,* namely, *Prototaxites Logani,* and *Nematoxylon crassum* and had been referred by Dawson to *Taxineæ* from its microscopic structure. Mr. Carruthers, however, shows that the fossil is not made up of wood-cells, but entirely consists of cellular filaments of two sizes, interwoven irregularly in a felted mass, and that its affinities are with the cellular Cryptogams. Reasons are given for placing it among the filamentous Chlorosperms, and the name is changed into *Nematophycus Logani,* Carr.

"In the Hamilton Beds" (Middle Devonian), writes Prof. Dana, "the evidences of verdure over the land are abundant."

"The remains show that there were trees as well as smaller plants; that there were forests of moderate growth, and great jungles over wide-spread marshes." "These terrestrial plants include *Lycopodiaceæ,* Ferns, and *Equisetaceæ,* the three orders of Acrogens, or higher Cryptogams, and also *Chara,* but no true mosses; and with these there were Gymnosperms or the lower *Phanerogams.*" (op. cit. p. 268.)

"Europe and Britain have afforded, in addition to sea-weeds, remains of plants mostly related in genera to those of the United States; so that the other continents besides America had their Ferns, Lycopodiaceæ, Calamites, and Conifers. Devonian plants have also been reported from Queensland, Australia." (op. cit. p. 283.)

In passing from the Devonian to the Carboniferous period no great difference is observable in the plant-remains. As in the later, so in the earlier, "there were Lycopods of the tribes of *Lepidodendron,* and *Sigillaria,* and various Ferns, Conifers and Calamites." "The

[1] "Some of the fossils, formerly regarded as indications of plants, are now believed to be worm-tracks or borings. But others show by their branching forms that they are true Fucoids." Dana's Manual of Geology, Revised Edition, 1874, p. 169.

[2] Monthly Microscopical Journ. vol. viii. Oct. 1872, pp. 160–172, pl. 31 and 32. See also Geol. Mag. 1873, Vol. X. p. 462, "Review of Fossil Botany."

vegetation may (even) have been as profuse for the amount of land, although the circumstances were less favourable for its growth and accumulation in marshes, the essential prerequisite for the formation of large beds of coal." (op. cit. p. 297.)

"The same genera of plants are represented among the European coal-beds as occur in America; and very many of the species are identical." "In this respect, the vegetable and animal kingdoms are in strong contrast; for the species of animals common to the two continents have always been few." (op. cit. p. 347.)

"The genera *Calamites, Sphenopteris, Pecopteris, Lepidodendron,* and *Sigillaria,* have much the largest number of species in Europe."

"Exclusive of fruits, there are about four hundred and thirty-four known American species and four hundred and forty European (and British); and of these one hundred and seventy-six are common to the two continents. In other words, about *two-fifths* of all the American species were also growing in the Carboniferous forests of Europe." (op. cit. p. 349.)

"Coniferous trunks and stumps are common through the Coal-measures. *Cordaites* are strap-shaped leaves, half an inch to an inch and a half wide, sometimes short, as in the Devonian species (*Cordaites Robbii*), and sometimes a foot or more long. They are often crowded together in great numbers in the slates overlying the coal-beds, and are common in other positions, thus showing that they were shed in great numbers by some plants of the period.

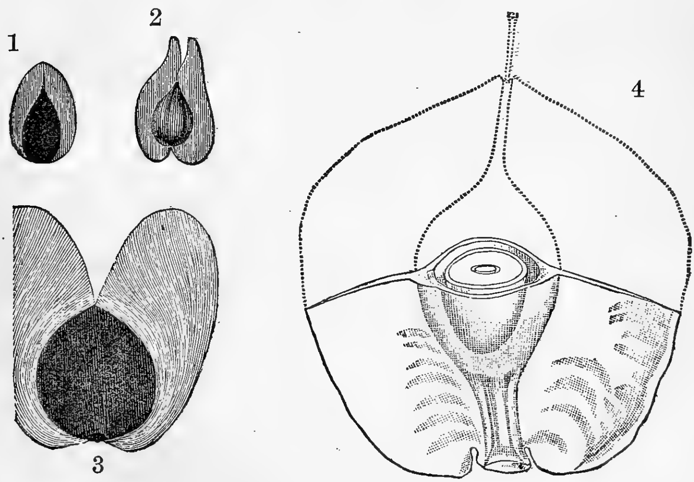


Fig. 1. *Cardiocarpus elongatus.*—Fig. 2. *Card. bisectus* —Fig. 3. *Card. samaræformis.*—Fig. 4. *Welwitschia mirabilis,* showing transverse section of fruit, with the outline of the fruit finished in dotted lines. [Reproduced by permission from Dana's Manual of Geology, Revised edition, 1874, p. 328.]

They have been referred both to the Lepidodendrids and to the Cycads, and by Schimper are embraced in Brongniart's genus *Pycnophyllum,* under the latter order. Geinitz has observed in

Saxony, and, later, Newberry, in Ohio, the winged fruits of the genus *Cardiocarpus* (see Woodcut, Figs. 1, 2, 3), associated with the leaves of *C ordaites*; and both have regarded it as highly probable that the fruit and leaves belong to the same plant. The nut-like character of the fruit separates *Cordaites* widely from the Lepidodendrids; and the fact that the leaves fell from the trees bearing them, instead of being persistent, and were simple instead of pinnate, removes them from ordinary Cycads, and affiliates the genus with Conifers, the other family of Gymnosperms. The South African Conifer,[1] *Welwitschia*, has both the broad strap-like leaves of *Cordaites*, and also, as shown in Woodcut, Fig. 4, the winged fruit of *Cardiocarpus*; sufficient to sustain the reference of the leaves and fruit to the Conifers, notwithstanding the anomalous character of the African plant." (Dana, op. cit. p. 329.)

It is not a little interesting to observe that in some "Notes on Fossil Plants," by William Carruthers, F.R.S. (Geol. Mag. 1872, Vol. IX. pp. 55-57), that gentleman has described two species of *Cardiocarpon*, namely, *C. Lindleyi*, Carr., Coal Measures, Falkirk, and *C. anomalum*, Carr., Coal M., Derbyshire.

5

6

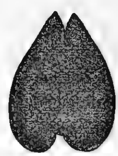


Fig. 5.—*Cardiocarpon Lindleyi*, Carr., Coal Measures, Falkirk.
Fig. 6.—One of the fruits enlarged twice nat. size.

Both these species have been described and figured by Mr. Carruthers from specimens having the fruits *attached to the plant*, and in Fig. 5 we reproduce *C. Lindleyi*, to show its close resemblance to the American species *C. bisectus* (Fig. 2).

We will refer our readers to Mr. Carruthers's admirable paper (which appears to have escaped Prof. Dana's eye), merely quoting the following:—"The aspect of the fruit, as it is ordinarily preserved, agrees remarkably with that of a single fruit of *Welwitschia.* It has an apparently winged pericarp, inclosing a seed, the integument of which is produced into a styliform process, that passes through a canal in the pericarp. But the thickened pericarp suggests a Taxineous fruit, with which, from the description I have given, it will be seen that it has many points in common. In *Taxineæ*, however, the fruit is terminal, generally solitary and sessile, with a more

[1] We cannot agree with Prof. Dana in speaking of *Welwitschia* as a Conifer. The order *Gnetaceæ*, to which it belongs, being separated by well-marked characters from the *Coniferæ*.

fleshy pericarp. On the whole, I am inclined to consider *Cardiocarpon* as a Gymnosperm of an extinct type, confined as far as is yet known to the Palæozoic rocks." (Carruthers, 1872, GEOL. MAG. Vol. IX. p. 56.)

Vast marshy plains seem to have characterized the period of the formation of the Coal-measures where "grew the clumsy Sigillarids and Calamites and the more graceful Tree-ferns, Lepidodendrids, and Conifers, with an abundant undergrowth of Ferns, and upon the dry slopes near by, forests of Lepidodendrids, Conifers, and Tree-ferns, and the luxuriant growth was prolonged until the creeping centuries had piled up vegetable debris enough for a coal-bed." (op. cit. p. 356.)

"The Coal-period was a time of unceasing change,—eras of universal verdure alternating with others of wide-spread waters, destructive of all vegetation and other terrestrial life, except that which covered regions beyond the Coal-measure limits. But yet it was an era in which changes for the most part went forward with so extreme slowness, and with such prevailing quiet, that, if man had been living then, he would not have suspected their progress, unless he had records of some thousands of years past to consult."

"According to the reading of the records, it was a time of great forests and jungles, and of magnificent foliage, but of few or inconspicuous flowers; of Acrogens and Gymnosperms, with no Angiosperms; of marsh-loving Insects, Myriapods, and Scorpions, as well as Crustaceans and Worms, representatives of all the classes of Articulates, but not the higher Insects, that live among flowers; of the last of the Trilobites (and we would add the last also of the gigantic old-world MEROSTOMATA the *Eurypteridæ*); the passing climax of the Brachiopods and Crinoids; of Ganoids and Sharks, but no Teliosts or Osseous Fishes, the kinds that make up the greater part of modern tribes; of Amphibians and some inferior species of true reptiles, but no Birds or Mammals; and therefore there was no music in the Groves, save that of Insect life and the croaking Batrachian. Thus far had the world progressed by the close of the Carboniferous period." (Dana, op. cit. p. 360.)

Since we received the copy of Prof. Dana's Geological Manual, the author has sent us the following note in reference to the enlargement of the new edition:

"While the number of pages is 30 greater than in the old edition, the *size* of the page is fully *one-fifth* larger; so that a page of the new edition contains very nearly a twentieth more matter than one of the old. The new edition, in fact, contains at least one-sixth more matter than the old."[1]

A further perusal of Dana's Manual has tended much to enhance our estimate of the vast and varied amount of geological materials brought together in so admirable and convenient a form for the use of the student. The illustrations, which exceed eleven hundred in number, are most admirably executed.

[1] We are also requested to make the following corrections:
On page 3, 8 lines from top, for 1-200,000th read 1-1200,000th.
On p. 129, 14 lines from top, for *Petremitids* read Pentremitids.
On p. 344, on Map, for 9 read 8, and for 8 read 9.

REPORTS AND PROCEEDINGS.

Geological Society of London.—I.—January 27, 1875.—John Evans, Esq., F.R.S., President, in the Chair.—The following communications were read :—

1. "On the Structure and Age of Arthur's Seat, Edinburgh." By John W. Judd, Esq., F.G.S.

The author said that Arthur's Seat, so long the battle-ground of rival theorists, furnished in the hands of Charles Maclaren a beautiful illustration of the identity between the agencies at work during past geological periods and those in operation at the present day.

One portion, however, of Maclaren's masterly exposition of the structure of Arthur's Seat, that which requires a *second* period of eruption upon the same site, but subsequent to the deposition, the upheaval and the denudation of the whole of the Carboniferous rocks, is beset with the gravest difficulties. The *Tertiary* and *Secondary* epochs have in turn been proposed and abandoned as the period of this supposed second period of eruption; and it has more recently been placed, on very questionable grounds, in the *Permian.*

The antecedent improbabilities of this hypothesis of a second period of eruption are so great, that it was abandoned by its author himself before his death. A careful study of the whole question by the aid of the light thrown upon it in comparing the structure of Arthur's Seat with that of many other volcanos, new and old, shows the hypothesis to be alike untenable and unnecessary.

The supposed proofs of a second period of eruption, drawn from the position of the central lava column, the nature and relations of the fragmentary materials in the upper and lower parts of the hill respectively, and the position of certain rocks in the Lion's Haunch, all break down on re-examination. While, on the other hand, an examination of Arthur's Seat, in connexion with the contemporaneous volcanic rocks of Forfar, Fife, and the Lothians, shows that in the former we have the relics of a volcano which was at first submarine, but gradually rose above the Carboniferous sea, and was the product of *a single* and almost continuous series of eruptions.

2. "The Glaciation of the Southern Part of the Lake-District, and the Glacial Origin of the Lake-basins of Cumberland and Westmorland."—Second Paper. By J. Clifton Ward, Esq., F.G.S.

The directions of ice-scratches in the various dales having been pointed out, the course of the several main glaciers was described, and it was shown how they must have become confluent in all the lower ground, forming a more or less continuous ice-sheet, which overlapped most of the minor ridges parting valley from valley, and was frequently forced diagonally across them.

The positions of certain ice-grooves having an abnormal direction were described; in several cases these cross lofty ridges at right angles to their direction, and generally at passes or depressions along a line of watershed. Most of those noticed had a generally east and west direction, and occurred at varying heights, from 1250 ft. to 2400 ft. The author, while acknowledging the difficulty attendant upon *any* explanation, was inclined, though somewhat doubtfully, to regard these abnormal markings as due to floating-ice, during the great period of interglacial submergence.

The moraines were all believed to belong to the last set of glaciers.

The subject of the "Glacial Origin of Lake-basins" was then entered upon, and the following lakes discussed by means of diagrams drawn to scale, showing lake-depths, mountain-outlines, and the thickness of the ice:—Wastwater, Grasmere, Easdale, Windermere, Coniston, and Esthwaite, together with several mountain tarns. In the case of Wastwater, the bottom was shown to run below the level of the sea for a distance of a mile and a quarter, and the deepest point to be just opposite the spot at which the only side valley joins the main one. While the greatest depth of the lake is 251 ft., the thickness of the old glacier-ice must have been fully 1500, and, all points considered, Prof. Ramsay's theory of glacial erosion seemed to the author certainly to be upheld. In like manner the same theory was thought to account for the origin of the other lakes mentioned, such ones as Windermere and Coniston being but long narrow grooves formed at the bottom of pre-existing valleys.

Mountain tarns were held to be due sometimes wholly to glacial erosion, sometimes to this combined with a moraine dam, and occasionally to the ponding back of water by moraines alone, or moraine-like mounds formed at the foot of snow-slopes.

II.—February 10, 1875.—John Evans, Esq., F.R.S., President, in the Chair. The following communications were read:—

1. "The Phosphorite Deposits of North Wales." By D. C. Davies, Esq., F.G.S.

The deposit of phosphate of lime described by the author is a bed varying from 10 to 15 inches in thickness, which occurs at the top of the Bala limestone over a considerable district in North Wales, having been detected in various localities from Llanfyllin to the hills north and west of Dinas Mawddy. The bed is rendered black by the presence of graphite, and appears to consist of concretions of various sizes cemented together by a black matrix. The concretions are richest in phosphate of lime, some of them containing 64 per cent.; the average amount in the bed, including the matrix, is 46 per cent. The deposit is underlain by a bed of crystalline limestone, and sometimes divided by thin beds of similar limestone into two or three layers. The author noticed the principal fossils occurring in the Bala limestone below the phosphorite beds, and stated that many of those in the overlying shales, up to a certain distance above the bed, are phosphatized. The author referred to the presence of phosphate of lime in the inner layers of *Unio* and *Anodonta* to the amount of as much as 15 per cent., and thought that the phosphate of lime in the deposit was probably of organic origin. It may have been an old sea-bottom on which the phosphate of lime of Mollusca and Crustacea was accumulated during a long period, and seaweeds may also have contributed their share. It probably represented the remains of an ancient Laminarian zone. The author suggested that the phosphatic nodules of the so-called coprolite beds in other parts of England might have been derived from the denudation of similar deposits.

2. "On the Bone-caves in the neighbourhood of Castleton, Derbyshire." By Rooke Pennington, Esq., LL.B. Communicated by Prof. W. Boyd Dawkins, F.R.S., F.G.S.

The author described as a Prehistoric Cave, the Cave Dale Cave situated in Cave Dale just below the keep of Peveril Castle. The upper earth in this cave contained fragments of late pottery mixed up (by rabbits) with bits of rude prehistoric pottery, a tooled piece of stag's horn, an iron spike, two worked flints, a piece of jet, part of a bone comb, and a bronze celt of peculiar form, many bones of *Bos longifrons* and goat, broken to get out the marrow, and remains of hogs; charcoal and human teeth also attested the occupation of the cave by man. There were also remains of fox, badger, cat, water-rat, dog, red deer, duck, fowl, and hare. Lower down were remains of *Bos longifrons*, hog, red deer, wolf, and horse; and lower still, next the rock, more human teeth, remains of animals, and a good flint. The cave seemed to have been occupied from time to time during a lengthened period, probably from the Neolithic age into those of bronze and iron. A cave in Gelly or Hartle Dale, contained, in blackish mould, bones (some broken) of goat, pig, fox, and rabbit, and pieces of very rude prehistoric pottery.

Of Pleistocene caves and fissures the author described several. One in Hartle Dale furnished remains of Rhinoceros, Aurochs (*Bison priscus*), and Mammoth, lying in yellow earth. The bones were probably carried in by water. A fissure near the village of Waterhouses, in Staffordshire, is six feet wide, and filled with the ordinary loam. Bones of Mammoths and the skeleton of a young Bison have been obtained from it, and the author supposes the animals to have fallen into the fissure while making for the river to drink. The Windy Knoll fissure is situated near Castleton, in a quarry near the top of the Winnetts, and close to the most northern boundary of the mountain limestone of Derbyshire. The author described particularly the situation of this fissure, and the drainage of the district in which it is situated. The fissure itself is filled with the ordinary loam, containing fragments of limestone, and inclosing an astonishing quantity of bones of animals confusedly mixed together, those lowest down near the rocks being coated with and sometimes united by stalagmite. The author supposes that this was a swampy place into which animals fell from time to time, and in rainy seasons their remains might be washed into it from the neighbouring slopes.

3. "The Mammalia found at Windy Knoll." By Prof. W. Boyd Dawkins, M.A., F.R.S., F.G.S.

This paper contained an enumeration of the remains of Mammalia found in the Windy Knoll fissure described by Mr. Pennington. They were stated to belong to the following species: Bison, Reindeer, Grisly Bear, Wolf, Fox, Hare, Rabbit, and Water-rat. Great quantities of bones and teeth were found, the number of individuals represented by the remains being given roughly by the author as follows:—

Bison	40–60
Reindeer	20–30
Grisly Bear...	4– 5
Wolf	7

From the great excess of Herbivorous forms, and the position of the fissure, the author assumed that the latter lay in the line of the annual migrations of the Bison and Reindeer, during which some individuals might fall in; and he explained the presence of the carnivores by their having followed the migratory herds, in order to prey upon stragglers, as is now the case with the Reindeer in Siberia, and the Bison in North America. He further showed, from the examination of the young teeth of the Bison and Reindeer, that these animals must have passed this way at different seasons of the year, and indicated that the deposit must be regarded as of Pleistocene age, though whether pre- or post-glacial is an open question.

III. — Annual General Meeting. — February 19, 1875. — John Evans, Esq., V.P.R.S., President, in the Chair.

The Secretary read the Reports of the Council, and of the Library and Museum Committee. The general position of the Society was described as satisfactory, although, owing to extraordinary expenses during the year, the excess of income over expenditure was but small in comparison with former years. The Society was said to be prosperous, and the number of Fellows to be rapidly increasing.

In presenting the Wollaston Gold Medal to Professor de Koninck, of Liège, F.M.G.S., the President addressed him as follows:—

Monsieur le Docteur de Koninck,—It is my pleasing duty to place in your hands the Wollaston Medal, which has been awarded to you by the Council of this Society in recognition of your extensive and valuable researches and numerous geological publications, especially in Carboniferous Palæontology. These researches are so well known, and have gained you so world-wide a reputation, that I need say no more than that your Palæontological works must of necessity be almost daily consulted by all who are interested in the fauna of the Carboniferous period. Already in 1853 the numerous and able Palæontological works which you had published in the preceding twenty years had attracted the grateful notice of the Council of this Society, who in that year begged you to accept the Balance of the proceeds of the Wollaston Fund, in aid of the publication of your work on Encrinites, then in progress. It was in the same year that the Society had the satisfaction of electing you a Foreign Member of their body; and now, after a second period of rather more than twenty years devoted to the study not only of Geology and Palæontology, but also of chemical analysis, I have the pleasure of conferring upon you the highest additional honour it lies in the power of this Society to bestow, by presenting you with the Medal founded by the illustrious Wollaston, who was himself also a Chemist as well as a Geologist. If anything could add to the satisfaction we feel in thus bestowing the Medal, it is your presence among us this day, which will enable you more fully to appreciate our unanimous sense of the high value of your labours in the cause which we all have at heart.

Prof. de Koninck, in reply, said: Monsieur le Président, Messieurs,—La langue Anglaise m'étant trop peu familière pour me permettre de m'en servir, afin de vous exprimer toute ma reconnaissance pour le grand honneur que vous venez de me faire, en me décernant la Médaille de Wollaston, j'espère que vous voudrez bien me permettre dans la circonstance solennelle dans laquelle je me trouve, de faire usage de l'idiome dont on se sert habituellement dans mon pays.

Laissez moi vous dire d'abord, Messieurs, qu'il m'a semblé que ma présence au milieu de vous, était le plus sur moyen de vous donner la preuve de mes sentiments de gratitude et du prix que j'attache à la distinction dont je vous suis redevable.

Cette distinction sera pour moi un nouvel encouragement et un stimulant pour continuer et pour achever, si possible, mes travaux concernant la faune carbonifère de mon pays. L'étude de cette faune, qui doit comprendre plus de 1200 espèces, m'a conduit à des résultats très remarquables. J'espère que je pourrai bientôt vous en fournir la preuve et vous démontrer qu'elle se compose de trois grands groupes parfaitement distincts entre eux, quoique possédant un certain nombre d'espèces identiques et dont le premier est presque exclusivement formé des espèces recueillies dans le calcaire de Tournai, le deuxième des espèces des environs de Dinant, et le troisième de celles du calcaire de Visé et de quelques lambeaux de ce même calcaire des environs de Namur.

Ces faunes sont principalement représentées chez vous, la première in Irlande, à Hook Point et ses environs, la deuxième aux environs de Dublin, et la troisième en Ecosse et au centre de Yorkshire, où elle a été l'object des remarquables recherches de notre savant et regretté confrère le Professeur J. Phillips.

C'est par ces travaux, Messieurs, que je compte terminer ma carrière scientifique, si les forces nécessaires et la santé ne me font pas défaut, et continuer ainsi à mériter votre haute et impartiale approbation.

The President then presented the Balance of the proceeds of the Wollaston Donation Fund to Mr. L. C. Miall, of Leeds, and addressed him in the following terms:—

Mr. Miall,—I have much pleasure in presenting you with the Balance of the proceeds of the Wollaston Fund, which has been awarded you by the Council of this Society to assist you in your researches on Fossil Reptilia.

Those who had the good fortune to be present at the meeting of the British Association at Bradford in 1873, and to hear the masterly Report of the Committee on the Labyrinthodonts of the Coal-measures, drawn up by yourself, and those also who have studied the Papers which you have communicated to this Society on the Remains of Labyrinthodonta from the Keuper Sandstone of Warwick, must be well aware of the thorough and careful nature of your researches, carried on, I believe, in a somewhat isolated position, and remote from those aids which are so readily accessible in the metropolis and some of our larger towns. I trust that the proceeds of this fund which I have now placed in your hands will be regarded as a testimony of the interest which this Society takes in your labours, and may also prove of some assistance to you in still further prosecuting them.

Mr. Miall, in reply, said that he felt that his sincere thanks were due to the Geological Society for awarding him the Balance of the proceeds of the Wollaston Donation Fund as a token of appreciation of the little work that he had been able to do, and also to the President for the terms in which he had been kind enough to speak of him. He should regard this donation, not only as an honour received by him, but also as a trust to be expended to the best of his power in accordance with the intentions with which it had been conferred upon him by the Society.

The President next handed the Murchison Medal to Mr. David Forbes for transmission to Mr. W. J. Henwood, F.R.S., F.G.S., and spoke as follows:—

Mr. David Forbes,—In placing the Murchison Medal and the accompanying cheque in your hands, to be conveyed to our distinguished Fellow, Mr. William Jory Henwood, I must request you to express to him our great regret that he is unable to attend personally to receive it. His researches on the metalliferous deposits, not only of Cornwall and Devonshire, but of Ireland, Wales, North-western India, North America, Chili, and Brazil, extending as they do to questions of subterranean temperature, electric currents, and the quantities of water present in mines, are recorded in memoirs which form text-books for mining students. They have for the most part been contributed to the Royal Geological Society of Cornwall, which has taken a pride in publishing them; but I trust that it will be a source of satisfaction to Mr. Henwood, after fifty years of laborious research, and amidst the physical suffering caused by a protracted illness, to receive this token of appreciation at the hands of another Society which takes no less interest in the subjects of his investigations.

Mr. David Forbes said that in receiving the Murchison Medal, on behalf of Mr. W. J. Henwood, he was commissioned by that gentleman to express his great regret that the bad state of his health and his advanced age prevented his appearing in person to thank the Council for the high honour they had conferred upon him, and the extreme gratification he felt in finding that the results of his labours in the investigation of the phenomena of mineral veins, which had extended over more than fifty years, had thus been recognized by the Geological Society of London.

The President then presented to Prof. H. G. Seeley, F.G.S., the Balance of the Murchison Geological Fund, and said:—

Mr. Seeley,—Your researches in Geology and on Fossil Osteology have now already extended over a period of upwards of sixteen years, and the numerous and valuable essays which you have contributed to the Annals and Magazine of Natural History, as well as to the Quarterly Journal of this Society, are only a portion of their fruits. Your separate works on the fossil remains of Aves, Ornithosauria, and Reptilia, in the Woodwardian Museum of Cambridge, and on the bones of Pterodactyles, are well known to every student of fossil osteology, and have been thought worthy of the by no means empty compliment of being printed at the expense of the Syndics of the University Press of Cambridge.

The esteem in which your researches are held by the Council of this Society, and their hope that you may still be enabled to prosecute them, are best evinced by their presenting you with the Balance of the proceeds of the Murchison Fund, which I now have the pleasure of placing in your hands.

Prof. Seeley replied as follows:—

Mr. President,—I have ever been taught that the Geological Society is the fountain of geological honour. It has always been a great honour to be associated with the Fellows of this Society, who are constructing the sciences we cultivate. Out of this association have grown bonds of comradeship, encouraging some of us to follow on in the labour of those whose work is ended; and when, Sir, I receive at your hands this award of the Balance of the Murchison Fund, I am grateful for such a distinguished mark of sympathy with my special studies, and shall be encouraged by it to prosecute researches which I hope may be better worthy of the Society's acceptance.

The President then proceeded to read his Anniversary Address, in which, after congratulating the Fellows upon their having at length got possession of their new premises, he called attention to the advantage which accrued both to the Fellows of the Society and to the officers of the School of Mines, Geological Survey, and Museum of Practical Geology, by the close proximity of the two establishments, and expressed a hope that there might be no severance of this union whether by the removal of the School of Mines to South Kensington or otherwise. He also contrasted the position of the Society as regards Funds, number of Fellows, etc., in 1829 and in 1875, the former being the first year in which the Anniversary Meeting of the Society was held in the Society's rooms at Somerset House. He then took up the main subject of his Address, namely, the question of the antiquity of the human race, and the geological evidence bearing upon it. The Address was prefaced by some obituary notices of Fellows and Foreign Members deceased during the past year, including Prof. Phillips, Dr. F. Stoliczka, the Rev. C. Kingsley, Mr. J. W. Pike, Dr. Arnott, Prof. W. Macdonald, M. Elie de Beaumont, and M. J. J. d'Omalius d'Halloy.

The Ballot for the Council and Officers was taken, and the following were duly elected for the ensuing year:—*President:* John Evans, Esq., F.R.S. *Vice-Presidents:* Prof. P. Martin Duncan, M.B., F.R.S.; Robert Etheridge, Esq., F.R.S.; Sir Charles Lyell, Bart., D.C.L., F.R.S.; Prof. A. C. Ramsay, LL.D., F.R.S. *Secretaries:* David Forbes, Esq., F.R.S.; Rev. T. Wiltshire, M.A. *Foreign Secretary:* Warington W. Smyth, Esq., M.A., F.R.S. *Treasurer:* J. Gwyn Jeffreys, LL.D., F.R.S. *Council:* H. Bauerman, Esq.; Frederic Drew, Esq.; Prof. P. Martin Duncan, F.R.S.; Sir P. de M. G. Egerton, Bart., M.P., F.R.S.; R. Etheridge, Esq., F.R.S.; John Evans, Esq., F.R.S., F.S.A.; David Forbes, Esq., F.R.S.; R. A. C. Godwin-Austen, Esq., F.R.S.; Henry Hicks, Esq.; Prof. T. McKenny Hughes, M.A.; J. W. Hulke, Esq., F.R.S.; J. Gwyn Jeffreys, LL.D., F.R.S.; Sir Charles Lyell, Bart., D.C.L., F.R.S.; C. J. A. Meyer, Esq.; J. Carrick Moore, Esq., M.A., F.R.S.; Prof. A. C. Ramsay, LL.D., F.R.S.; Samuel Sharp, Esq., F.S.A.; Warington W. Smyth, Esq., M.A., F.R.S.; H. C. Sorby, Esq., F.R.S.; Prof. J. Tennant, F.C.S.; W. Whitaker, Esq., B.A.; Rev. T. Wiltshire, M.A., F.L.S.; Henry Woodward, Esq., F.R.S.

CORRESPONDENCE.

MR. BIRDS ON THE IRISH GLACIAL DRIFTS.

Sir,—In a paper in the Geological Magazine for Feburary, "On the Post-Pliocene Formations of the Isle of Man," the author, Mr. J. A. Birds, intimates that an Upper Glacial Drift with underlying "Middle Gravels" has been proved to exist in the east of Ireland. If, however, this observer had read all the evidence on the subject, he would know that if such divisions exist, they have never yet been found.[1] If such drifts exist, they ought to be found in some of the cuttings for the numerous lines of railway that traverse Ireland; but as yet no section showing them has been exposed. In the east of the Island they might be expected to be found, in the cuttings for the railways between Dublin, Belfast and Larne, or Belfast and Newcastle, or Dublin and Wexford; yet they have not been exposed; and if they did exist, they could scarcely have been passed over in the cuttings between Drogheda and Belfast. In the Dublin and Wexford railway, north of Killiney hill, and both N. and S. of Bray Head, there are indeed Boulder-clays, that a casual observer might suspect to be normal Glacial Drift; but a very slight examination ought to satisfy him that these suspected Upper Glacial Drifts were members of the Gravel Drifts; having been either talus, due to the weathering of a Glacial Drift cliff, or slips from the latter, that had covered sands and gravels, which had accumulated at the base of the cliff. In the east of Ireland the only place where there seems to be drifts at all likely to be Upper Glacial Drift and Middle Gravels, is at the Mourne mountains, on the west coast of Dundrum Bay, and in the Mourne Demesne; but in both places a very brief examination will show that the upper member of the sections cannot be normal Glacial Drift. The writer of the paper to which I allude has evidently fallen into the mistake made by so many writers of the present day on Drift,—that is, of including in Glacial Drift all Boulder-clays, if glacialoid, and also the associated gravels and the like; while it is evident that all stratified Boulder-clays cannot be *normal* Glacial Drift; for since the materials were imbedded in ice, they must have been re-arranged by water; while many unstratified Boulder-clays cannot be normal Glacial Drift, as their present position is due to the slipping or weathering of cliffs. All gravels, sands and the like, cannot possibly be called Glacial Drift, as they have been not only re-arranged, but also sorted, sifted, and transported, since they came out of the ice.

If the age of the Glacial Drift is allowed to be proved by such loose evidence as that which is now so commonly in vogue, proofs might be adduced that it is in course of formation, even up to the present moment. In numerous places cliffs of Glacial Drift exist, at the base of which sands, gravels, alluvium, and peat are accumulating, or human works are being constructed. These cliffs in time must form slopes, either by weathering or slipping: and thereby cover up what

[1] See Middle Gravels (?), Ireland, Geol. Mag., 1872, Vol. IX. p. 265, and Glacialoid or Re-arranged Glacial Drift, Geol. Mag., March and April, 1874.

is at their base. This will prove, if the line of argument at present in use be allowed, that all their recent accumulations, and even the railways, are pre-glacial. I have seen from ten to twenty feet of as good Glacial Drift as that from which the existence of the Middle Gravels have been proved (?), covering a recent railway, or some other modern structure; and I have heard such covering pronounced "good typical Glacial Drift" by an eminent geologist before he was pointed out what was beneath it.

G. Henry Kinahan,
Irish Branch, H.M. Geol. Survey.

Wexford, Feb. 6, 1875.

GEOLOGICAL SURVEY OF YESSO.

Sir,—While thanking you for the kindly notice (in the last received number of your Magazine, October, 1874) of my little report of a year ago on the first season's field-work of the Geological Survey of Yesso, I beg to make a correction in the criticism on the topographical-geological method of Prof. Lesley (chief of the new Pennsylvania Geological Survey). He should not be blamed for the "confusion and unsightliness" of the lines on a map that shows the contours of the principal beds of rock as well as of the surface; for his maps are models of clearness and taste, and even on a large scale commonly show for the rocks only the outcrop and the lowest natural drainage level of the beds of chief mining importance, and the topography is often reinforced by shading, besides the contour-lines. The addition of contour-lines for such beds above water-level, and to a certain depth below, is my own idea, and what I fondly imagined to be an improvement, especially in mapping limited tracts of land where the owners wish to see at a glance as by a sort of cross-hatching on the map what portion of the ground is underlain by workable beds. In many regions, perhaps most, it is possible to draw such underground contour-lines with a degree of accuracy very useful for practical mining purposes (one coal-bed, for example, was shown by a map to be at 180 feet below the surface of the ground at a point three-quarters of a mile from the nearest exposures of the bed, and on sinking a pit proved to be at 182 feet). The rocks are not in every country tied up in double bow-knots, as they sometimes seem to be in the Himalayas. Of course it is difficult to trace out such contortions, or to represent them on a map in any way; for even every small irregularity in the surface-contours cannot be given on maps of small scale.

It must be admitted that to draw two sets of contour-lines on the same map, especially if both are black for photographing, necessarily takes away somewhat from the good appearance of either alone; but is there not some compensation in the additional information conveyed, and in the display of the relation of the surface-contours to the underground contours at every point? It must also be acknowledged that "observations made at the surface can only be taken for what they are worth," and the underground contours of a bed of rock must always be somewhat less certain than those of the surface. Still, is it not worth while for the observer to give precisely what, from his study, seems to be the true position of the beds, without, however, exaggerating the certainty of such results? At any rate, no matter how the final map may be drawn, it is hard to conceive of any way but Lesley's (more or less perfectly followed) for making out a continuous section of rocks that are exposed only at intervals either on one stream or on different sides of a hill, if the fossils or the resemblance of beds are not (as commonly happens) a complete guide.

You seem rather inclined to regard the hope that my Japanese assistants should become accomplished geologists "in a few years" as an "Oriental exaggeration." But I still see no reason to attach a special geological sense to the expression; though it is not to be supposed that they could advance far more rapidly than we self-satisfied Anglo-Saxons. Most of them can already make topographical maps with a facility that is unfortunately rare not only among geologists, but even among railroad engineers.

In speaking of the report it would perhaps not be amiss to commend the Japanese for making public even so small a contribution to geology, not only in their own language, but in one more readily understood by a foreign scholar; the first case of the kind under any native Asiatic government. It is still doubtful whether they will be willing to publish in like manner more voluminous local details with maps and sections. BENJ. SMITH LYMAN.

KAITAKUSHI, SHIBA, YEDO,
9th January, 1875.

QUESTIONS CONCERNING THE GEOLOGICAL ACTION OF ICE.

ADDRESSED TO THE OFFICERS OF THE ARCTIC EXPEDITION.

I HAVE been led by a long series of observations on the drifts and boulders of the north of England and Wales to conclude that we cannot arrive at a consistent and satisfactory explanation of glacial phenomena until more light has been thrown on many questions, including the following: Is the *interior* of the Greenland *ice-sheet* or *ice-sheets* free from rocky débris, or is it more or less charged with it? Is the *base* of the Greenland ice capable of pushing forward large stones to great distances? Is it capable of holding stones of considerable size firmly fixed in its grasp, or of polishing and uniformly striating any stones *not* fixed in the subjacent ground? What is the state of the *base* of icebergs as regards being charged with clay, sand, small stones, or large boulders? Can a *grounding iceberg* give a rounded as well as a flat shape to the surface of submarine rocks, or, while endeavouring to regain its normal level, striate a rock-surface down-hill? Can a *revolving* iceberg scoop out a hollow in the rocky bottom of the sea? To what extent can *coast-ice* transport earth, stones, and large boulders? Are there any instances, in the Arctic regions, of floating coast-ice radiating from islands so as to distribute rocky débris over an area of 90 degrees? Are there any conditions under which floating coast-ice, "charged throughout with detrital matter," may deposit dome-shaped masses of concentrically-shaped laminæ, or masses of alternately fine and coarse detritus in an irregular and complicated order of succession? To what extent does moving or floating coast-ice smooth and striate rock-surfaces, or give rise to *roches moutonnées*? To what extent may moving or floating coast-ice, while grounding, be capable of flattening and smoothing the pebbles fixed in its base? Can it produce a series of *clearly-cut* and *parallel* grooves on the flattened surface? In the marine Boulder-clay of Cheshire there are many pebbles which have been flattened and uniformly striated on *two opposite sides*. Are there any conditions under which the mode of action of moving or floating coast-ice may be supposed capable of giving rise to such a phenomenon? How far, in the Arctic Seas, is the course of surface-currents carrying sea-ice crossed by that of under-currents carrying icebergs? Do these currents ever flow in diametrically opposite directions?

2, Abbey Court, Chester. D. Mackintosh, F.G.S.

MISCELLANEOUS.

The Chair of Natural History in the University of St. Andrews has been offered to and accepted by Professor Alleyne Nicholson, of the College of Physical Science, Newcastle-on-Tyne. Dr. Nicholson was in no way a candidate, directly or indirectly, for this appointment; but in thus offering it to him unsolicited, the Marquess of Ailsa has the cordial approbation of the University authorities, and may be congratulated in securing for the chair, of which he is patron, so distinguished a naturalist and professor, whose experience extends over two continents.—*Scotsman*, February 22, 1875.

Sub-aerial Denudation.—In the Registrar-General's annual return for 1872, which was printed March 10th, attention is drawn to the excessive rain-fall. The total fall of rain was enormous, and each of the last three months of the year showed an excess. During the quarter rain had fallen at Greenwich on sixty-seven days, a greater number than had been previously experienced as far back as the year 1815. The total fall in the sixty-seven days amounted to 11·32 inches. It has been shown that an inch deep of rain weighs nearly 101 tons per acre, so that upwards of 1,100 tons of water fell in the last three months of the year on each of the 37,000,000 acres of England and Wales!—*Daily News*, 11th March, 1875.

The Lyell Medal and Fund.—Sir Charles Lyell has bequeathed to the Geological Society of London the sum of £2000, together with the die of a medal, to be called "the Lyell Medal." Not less than one-third of the annual proceeds of the Fund is to be awarded with the Medal. The Balance to be given in any proportions that the Council may see fit. The recipients may be of either sex, and of any country; and the award may be made for work done, or to assist in present researches, or for memoirs on Geology and the allied sciences. The bequest and the terms in which it is made are alike worthy of so great a name as that of Lyell.

THE
GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. II.

No. V.—MAY, 1875.

ORIGINAL ARTICLES.

I.—The Search for Coal under the "Red Rocks" of the South Staffordshire Coal-field.

By Charles Ketley, Esq.

IT is now fifteen years since the appearance of the second edition of the late Professor Jukes's memoir on the Geology of the South Staffordshire Coal-field. The author observed in his preface that a revision of his work had been rendered necessary by the opening of many new mines and cuttings of various kinds which had afforded fresh information on points that had previously been obscure. He mentioned, for instance, certain red clays and sandstones occurring at Walsall Wood, and at other places which were at first supposed to belong to the New Red Sandstone, afterwards believed to be Permian, but were ultimately decided to be Coal-measures.

Similar terms would now help to show the necessity for a third edition. New sinkings have afforded new information, and certain other red beds believed to be Permian have proved to be Coal-measures.

Whoever undertakes the revision and the supplementary work for a new edition will find abundant material, and among the sinkings claiming his attention will be that, recently completed, through the red rocks of West Bromwich, at Sandwell Park, on the estate of the Earl of Dartmouth.

In connexion with these red rocks a passing notice may be made of the first search for Coal, thirty-six years ago, by the late Earl of Dartmouth, who, in the face of the prevailing belief that no Coal existed under the red rocks, sunk his famous Heath Pits. These were commenced at the suggestion of his principal agent, Mr. Dawson, a gentleman who, without being versed in mining affairs, simply applied, in this case, the knowledge he had derived from geological writings, especially those of Sir Roderick Murchison. That celebrated geologist, from observations made in the old Coal-field, had inferred the existence of Coal under the "Lower New Red Sandstone," as the red rocks on the margin of the Coal-field were then named.

Lord Dartmouth's experiment, much ridiculed by practical miners, was ultimately successful, and was the beginning of the opening up of a new tract of Coal-measures three-quarters of a mile in width, extending from the "Eastern Boundary Fault" to the Heath Pits. This addition to the productive area of the Coal-field has since been extensively worked by numerous sinkings, some of which are noticed below.

But while the Heath sinking had established the existence of Coal under the Lower New Red Sandstone, and beyond what was formerly considered the eastern barrier of the Coal-field, it seemed to prove also the existence of another "barrier." There was no "thick" Coal in the shaft of the Heath Pit; thin coals only were found, and it came to be concluded that these occupied the place of the thick Coal, or represented its thinning out. In search of the thick Coal, a "heading" from the shaft was driven eastward, and at the extremity of this a boring was made upwards, striking "red rock," and another boring was made downwards, reaching a hard rock, which afterwards was believed to be of Silurian age. After these unsuccessful attempts, one of the thin coals in the shaft was followed to the west, in the direction of the old Coal-field, and that led into the thick Coal.

Sir Roderick Murchison concluded that the shaft proved to be sunk upon a line of dislocation, the prolongation of the upcast of the Silurian rocks of Walsall and Tame Bridge.

Professor Jukes considered there was a sudden rise of Silurian rocks through the Coal-measures forming a bank, the existence of which had been favourable to the formation of sandstone and the accumulation of clay, but unfavourable to the formation of Coal. From Silurian shale having been found in a coal-pit at Langley Mill, Oldbury, he supposed the bank to be continuous for that distance, about three miles, and he indicated the probable course of it by a dotted line drawn on the map of the Geological Survey.

Professor Hull looked upon this Silurian bank as part of the original margin of the Coal-field, and supposed it might be traced southwards to the Lickey district. He held that east of this margin there could be no Coal.

There were different opinions as to what lay east of this Silurian bank, but none were favourable to the existence of workable Coal-measures. The sections of the following sinkings, in the tract above referred to, were supposed to show varying thicknesses of red rocks, held to be Permian, overlying varying thicknesses of recognized Coal-measures supposed to have been denuded. Reasoning from these and other appearances, it was concluded that further eastward a still greater thickness of Permian beds rested upon Coal-measures still more denuded:—

	Permian over Coal-measures.	Coal-measures over thick Coal.
Lewisham Pits	315 feet	520 feet
Lyng Colliery	550 "	350 "
Heath Pits	806 "	40 "
Bullock's Farm Pits...	700 "	330 "
Unitt's Boring at the "Ruck of Stones"	664 "	Abandoned.

The position of the boring at the "Ruck of Stones" was more than a mile east of Bullock's Farm Pit, and the general rise of the strata to the west being at an angle of about 10 degrees, it followed that a good part, if not the whole of the 700 feet of Permian at Bullock's Farm, must be below the 660 feet passed through at the "Ruck of Stones," from which Jukes concluded "there must be in the neighbourhood of West Bromwich a total thickness of 1500 feet at the very least, composed of rocks of the Permian formation." (South Staffordshire Coal-field, page 12.)

After pointing out that in the southern part of the Coal-field we have nearly or quite a thousand feet of Coal-measures over the thick Coal, without including any Permian, Jukes remarks upon the lesser thicknesses of Coal-measures shown in the above sections: "We have in these facts a clear case of unconformability between the Permian beds and the Coal-measures. We see that after the Coal-measures had been deposited they had suffered largely and very irregularly from denudation, several thousand feet of strata having been removed from one place, which were left untouched at another, before the Permian beds had begun to be deposited upon them." . . . "It is perhaps rash to generalize from the very scanty data we possess as to the precise relations between the Permian and Coal-measures. On so important a point, however, it is, I believe, a duty to state every opinion that may be fairly arrived at. I will therefore state, as my belief, that not only near West Bromwich, but *generally* in South Staffordshire and *the adjoining counties,* the Coal-measures suffered very generally from denudation before the deposition of the Permian, and that the Red Sandstones of that formation were largely deposited in hollows and excavations worn in the Coal-measures by this denudation; and, moreover, that this excavation and denudation had in places proceeded to the length of being continued right through the Coal-measures down to the rocks below." (South Staffordshire Coal-field, page 136.) And he says further, "It is probable that a little further east of the Heath Pits, the Coal-measures are entirely wanting, and the 'red rocks' of the Permian formation rest directly on the shale or 'bavin' of the Silurian formation. This, then, would be one of those cases where the denudation of the Coal-measures had proceeded the length of totally removing that entire series of rocks previously to the deposition of the Permian beds." (South Staffordshire Coal-field, p. 139.)

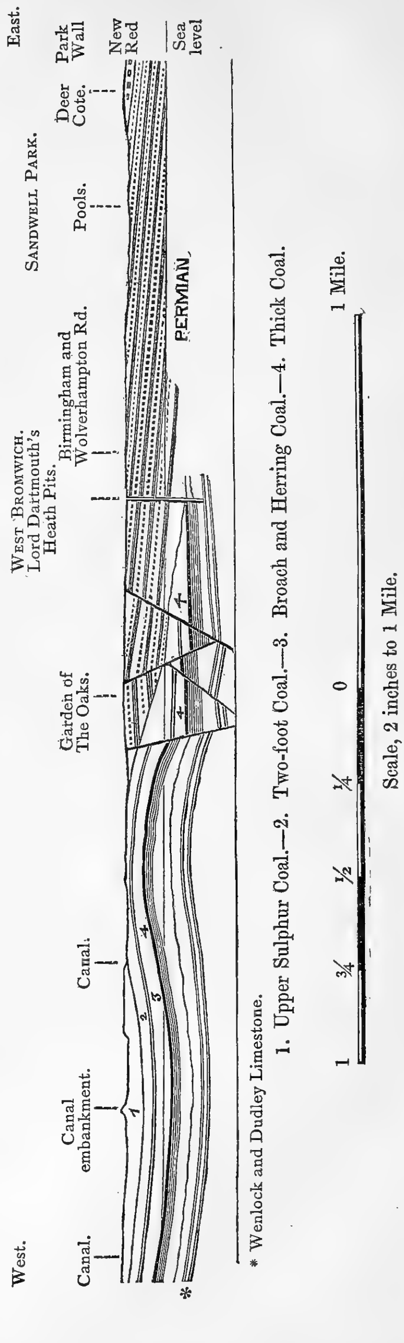
The conclusions then of some of the highest geological authorities were that a Silurian bank, running north and south from West Bromwich, cut off the Coal, and that east of that bank a great thickness of Permian rocks would be found to overlie denuded Coal-measures, or else to rest upon older rocks. This view of the case is well shown in the following horizontal section taken from the Geological Survey, Sheet 25, No. 7 E. and W., "through Kingswinford, Dudley, and West Bromwich." (See page 196.)

Or, supposing there had been no denudation, and the rocks to lie in their natural thicknesses, then any one sinking for Coal was warned that he must calculate upon the possibility of having to go through 1500 feet of Permian *and* 1000 feet of Upper Coal-measures, before reaching the place of the thick Coal.

So long a time having elapsed after the publication of these opinions without further trial being made to find Coal under the red rocks proves how generally the warning had been taken. At last the Sandwell Park Colliery Company, under the guidance of Mr. Henry Johnson, ventured to try this doubtful ground; and their enterprise has been rewarded by the finding of the thick Coal, as well as other Coals and Ironstones common to the old Coal-field.

Besides yielding to the explorers the object of their search, the Sandwell sinking has afforded evidence enabling us to perceive that the red rocks of Bullock's Farm and the other West Bromwich sinkings hitherto classed as Permian are in fact Coal-measures.

In the Sandwell shaft, at the depth of 110 yards, in red measures, were found numerous fossil plants, that on being submitted to proper authorities for examination were pronounced to be Permian. At 200 yards a seam of Coal seven inches in thickness was found; overlying the Coal was a black shale full of fossil plants, and underneath the Coal was a bed of fire-clay containing *Stigmaria.* Several of the plants in the roof-shale at 200 yards proved to be specifically identical with others among those found in the red beds above mentioned, showing that at the depth of 110



* Wenlock and Dudley Limestone.

1. Upper Sulphur Coal.—2. Two-foot Coal.—3. Broach and Herring Coal.—4. Thick Coal.

Scale, 2 inches to 1 Mile.

yards, if not earlier, the sinkers entered the Coal-measures. A second seam of Coal six inches thick was met with at 230 yards, and a third seam of the same thickness at the depth of 244 yards. From this third Coal to the thick Coal the depth was 174 yards.

As to the 110 yards overlying the first observed fossils, it seems that, if any Permian beds form a part of that thickness, they are wanting in those characters by which we have been accustomed to distinguish the Lower Permian rocks from the Coal-measures.

Sandwell Pit, being one mile east of Bullock's Farm Pits, and all the beds rising to the west, it follows that the red beds of Bullock's Farm and the other West Bromwich sinkings, rise from beneath the Upper Coal-measures of Sandwell. So that there is not, as there was supposed to be, a great thickness of Permian beds deposited upon denuded Coal-measures, or occupying the place of Coal-measures entirely swept away, or resting upon older rocks. On the contrary, we have Coal-measures throughout the greater part of the sinkings.

Thus, with respect to the red rocks of West Bromwich, the Sandwell sinking teaches that the position in the geological scale of, at least, the greater part of them had been misunderstood for want of better evidence, and that they are not Permian, but Coal-measures.

It must be evident there is more in this fact than a mere change in classification, and that it is of great interest and importance as bearing upon the question regarding the depth of the Carboniferous rocks, "not only near West Bromwich, but," perhaps, "generally in South Staffordshire and the adjoining counties."

The opinion of Professor Jukes as to the thickness of the Permians and of the Coal-measures, quoted above, was based principally upon the evidence afforded by Bullock's Farm and the other West Bromwich sinkings. In his chapter on the Permian rocks of the South Staffordshire Coal-field, he says:—"There are two parts of the district, from the examination of which it is possible to arrive at a tolerably complete notion of the structure and sequence of the Permian rocks, namely, the country about the Lickey and the Clent Hills, and the neighbourhood of West Bromwich." (South Staffordshire Coal-field, page 9.) In estimating the depth at which profitable Coal-measures might lie, the thickness of red rocks, which was known approximately, was added to an almost equal thickness for Upper Coal-measures *supposed* to underlie the red rocks; but now that the red rocks themselves prove to be Upper Coal-measures, we see that the thickness of the Upper Coal-measures has been reckoned *twice over.* Had Jukes possessed such evidence as Sandwell now gives, not only would he have seen the probability of Coal underlying extensive untried tracts, but his estimate of the depth at which the Coal might be won would have been reduced by leaving out a great part of the 1500 feet reckoned for the thickness of the Permian.

The Sandwell section exhibits a greater thickness of Coal-measures over the thick Coal than had been opened up previously. Its highest beds appear to be new. The three little Coals were not before known as a series, but it is probable the 9-inch Coal met with in Bullock's Farm Shaft at 70 yards from the surface is one of the same series. Probably, in other sections in various parts of the Coal-field, some of these higher Coal-measures may be traced, suggesting that a much greater thickness of Upper Coal-measures than we at present know of spread over the whole extent of the Coal-field previous to its elevation and denudation.

Stimulated by the Sandwell success, other companies are forming to search for Coal under the red rocks of large estates situate still further away from the "eastern boundary" of the old Coal-field than Sandwell. Is it not probable that still higher Coal-measures may be recognized? Is it not possible that the *Spirorbis Limestone* may yet be found over all, to prove the relation between the South Staffordshire and the Warwickshire Coal-fields on the one hand, and the Wyre Forest Coal-field on the other?

II.—On the Gault *Aporrhaïdæ.*

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

(PLATE VI.).

(*Continued from page* 130.)

Group 4.—Spire moderately long, generally without carinæ, always ribbed transversely. Wing expanded and quadrate, prolonged posteriorly into a sharp point.

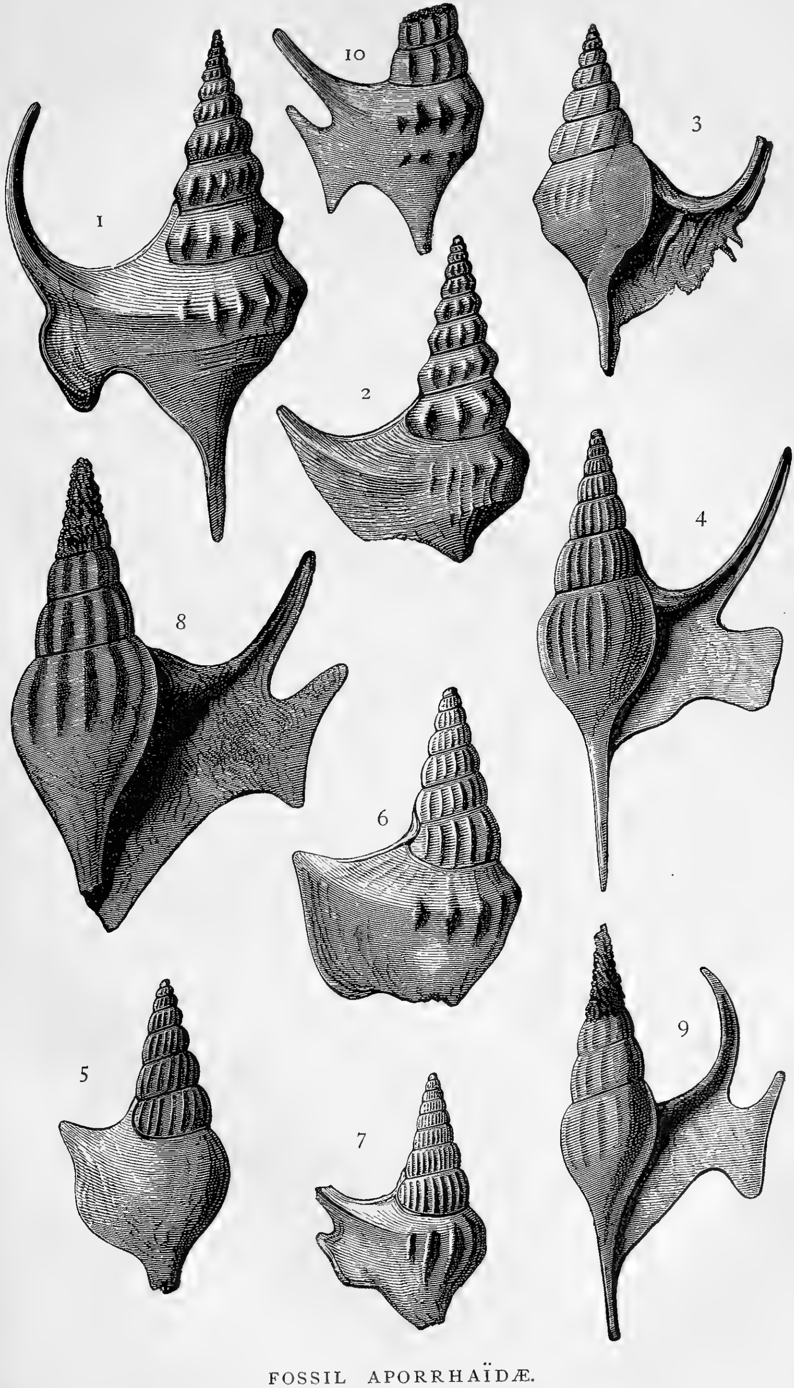
Type:—A. Parkinsoni.

Aporrhaïs marginata, Sowerby. Pl. VI. Figs. 1, 2, 3.

Synonym: A. Orbignyana, Pictet, and Roux.

Description.—Shell elongated, the spire forming an angle of 33° and measuring ·046: composed of eight convex angulated whorls, which are closely covered with spiral striæ, each alternate one being nearly twice as prominent as the intervening one. The whorls are ornamented by short elongated ribs, which are nodose and tubercular on the lower, but thin and linear on the upper whorls, and more numerous and very fine towards the apex. These ribs have an occasional tendency to form varices. On the body-whorl there are two more or less distinct rows of tubercular nodes; the uppermost row, being the more important, is continued in the form of a tuberculated ridge on the wing process. The wing is large, broad and quadrate, and thickened in the same manner as in the recent *A. pes-pelicani*, which our shell much resembles. It is sinuous at its margin, and terminates anteriorly in a blunt process; posteriorly ending in a long and rather recurved sabre-shaped spike, deeply grooved ventrally. Between this and the margin of the remainder of the wing is a sinus. The mouth is narrow, and shaped, as in *A. pes-pelicani*, like a lance-head point downwards. The anterior canal is moderately long, ·021, delicate and straight. The inner lip and underside of the pterygoid process are enamelled; length of the wing to the end of spike is ·032. Fig. 3 represents a variety from an upper bed in which the ribs continue thin and linear to the last whorl, instead of being nodose or tubercular.

Distribution.—Found most abundantly at Folkestone, where it



FOSSIL APORRHAÏDÆ.

occurs in all the beds of the Gault; also at Lyme Regis and Cambridge; on the Continent it is found in the Paris and Mediterranean basins, Switzerland, and at most places where the Gault occurs. Specimens with exaggerated varices are met with at St. Florentin.

History.—It was named *R. marginata* by Sowerby in 1836, who figured a fragment of the spire in the *Geol. Trans.* vol. iv. pl. 11, fig. 18, pp. 114 and 365, from the Gault of Kent. His description is, however, not clear, and applies equally to *A. carinata.* The figure is drawn from a specimen which has the shell partly preserved in the spire, but only the cast of the body-whorl remains; in consequence of this, and of the want of clearness in the engraving, the second anterior keel scarcely shows. As a result, and from no mention being made in the description of the two keels, all Continental and most English writers, supposing Sowerby's form to have but one keel, re-named the species *A. Orbignyana,* which really is invariably bicarinated. In the same year, 1836, Michelin, in the Mém. Soc. Géol. t. iii. p. 100, quoted Sowerby's description, but named the shell *R. costata.* In 1838 D'Archiac included *R. marginata* in his lists from Novion and St.-Pot; and in 1842 Leymerie notices it from Ervy. Again, in 1842, D'Orbigny figured it as *R. Parkinsoni* (not of Mantell) in the Terr. Crét., adding a variety of localities to those previously known. In 1850 he entered it in the Prodrome, both as *R. costata* and as *R. submarginata.* In 1849 we find this shell named *R. carinella* (not D'Orb.) by Pictet and Roux, who figured it from the Gault of Saxonnet, etc.; but in 1853 they re-named it *R. Orbignyana,* a name by which it has since been generally known. It has been cited under various names, generally as *R. costata,* by many authors. In 1857 by D'Archaic from the Pas-de-Calais; in 1853 by Studer from Ste.-Croix; in 1854 by Renevier from the Perte-du-Rhône; in 1854 by Cotteau, and in 1857 by Raulin and Leymerie, from the Yonne; and in 1857 by Ebray from Cosne. In Morris's Catalogue, 1854, it is called *marginata.* From 1859 it has been known exclusively to European authors under its specific name of *Orbignyana*; see Desor and Gressly, Pictet and Campiche, Gabb, Jaccard, etc. In 1864 Pictet and Campiche described a variety as *A. obtusa,* but it is possible that their specimens may have been casts of *A. marginata*; whilst perhaps some of the more elongated casts, they thought to be of *Orbignyana,* are *A. carinata,* a species otherwise absent in Switzerland. In 1865 Mr. R. Tate described this and *marginata* as separate species, failing to see that they were identical.[1]

Pictet and Campiche adopted Sowerby's name *marginata,* and applied it to a species with a single keel on the body-whorl, a form which their fig. 2, pl. xciv., shows to be identical with *A. maxima* of Price. Their statement, that they "possess specimens from Folkestone which prove the identity of this type with ours," is difficult to reconcile with their figures and descriptions; it is, however, absolutely certain that *Sowerby's marginata is identical with Orbignyana of Pictet and Roux.*

[1] Geol. and Nat. Hist. Repertory, 1865.

The form of the shell recalls *A. Parkinsoni*, Mant., with which I have grouped it, but the tuberculated nodes, thickness, and difference in form of wing, and the nodosely keeled appearance of the last whorl, are characters which should have rendered confusion impossible.

The following are closely allied species, and are from the Gault:—*A. Drunensis*, D'Orb.; *A. fusiformis*, P. and R.; *A. pseudosubulata*, d'Orb.; *A. obtusa*, P. and C.; *A. Varusensis*, d'Orb.

Aporrhaïs Parkinsoni, Mantell. Pl. VI. Figs. 4, 5, 6, 7.

Description.—Shell elongated; the spire forming an angle of about 30°, is composed of 9 or 10 convex whorls, which are finely striated spirally, the striæ being sometimes wider apart in front of the suture. Each whorl is rather irregularly ornamented by 16 to 20 or more, slightly flexuous, slender ribs, which have, though rarely, a tendency to produce varices. The body-whorl is wholly destitute of carinæ, and is prolonged in a broad rounded expansion obliquely truncated at the extremity and sinuous at its anterior margin, where it unites with the canal; there is at the posterior margin a deep sinus equal to half the length of the wing, and above this sinus is a long recurved canaliculated point, in some species nearly equal to the length of the spire and accompanying it, but at a considerable angle. On the wings the continuation of the striæ is interrupted and disconnected by rather strongly marked lines of growth crossing them, giving it a somewhat reticulated appearance. The wing is much thinner than in *A. marginata*. The aperture is narrow, and the anterior canal moderately long.

The Blackdown specimens are usually of rather smaller size, the ribs slightly more prominent, and with a greater tendency to produce varices. The sinus in the wing is not so deep, and the anterior canal is shorter.

This species is easily distinguished from all others of the Gault by the rounded appearance of the last whorl, its elongated ribs, and by the form of the wing. The superior prominence of the striæ in front of the sutures is not an important character, although considered to be such by Pictet. A number of similar forms are described by Continental authors, none of which appear to be identical with this or the next species. This form of shell seems more especially to characterize the Chalk, representatives being found in all parts of Europe. It is very like *A. occidentalis* of recent times.

Distribution.—It is found abundantly at Folkestone, Cambridge, and Blackdown; also at Sidmouth, and in the ferruginous nodules of Shanklin and other Lower Greensand (Neocomian) localities. Fitton and Mantell give it an extended range in the Chalk, but this range belongs more probably to the next species. On the Continent it is common to the Gault of the Paris and Mediterranean Basins, and to Switzerland. Specimens from St. Florentin have extravagant sutures, and approach *A. Mantelli* by the prominence of their ribbing.

History.—This species was first figured by Parkinson in his Organic Remains, 1811, vol. iii. p. 63, pl. 5, f. 11, from a *Blackdown specimen.* In 1822 Mantell, in the Geology of Sussex, p. 72, described a Blackdown specimen, and also, p. 108, one from the Grey Chalk. He says: "This species occurs in the Greensand of Devonshire, and is figured in the third volume of Organic Remains. As it has not received a specific appellation, I have named it from my excellent friend James Parkinson, Esq., M.G.S." It is therefore evident that, although he confounded the Greensand with the Chalk species, the Blackdown specimen figured by Parkinson he intended to bear the name *Parkinsoni*. The figures in pl. xviii. are unfortunately of not much value.

This error of Mantell has led to much misunderstanding and confusion.

In 1827 Sowerby, in the Mineral Conchology, pl. 558, figs. 5 and 6, re-figured Parkinson's original examples from Blackdown, but unfortunately included under the same name a quite distinct London-clay species, now known as *A. Sowerbii*. He again figured the Blackdown fossil for Fitton in the Geol. Trans. 2nd series, vol. iv. pl. xxviii. In 1839 Geinitz, in his work on the Saxon and Bohemian Cretaceous Series, figures some imperfect and doubtful specimens as *R. Parkinsoni*, but considers that Mantell had figured a different species from Sowerby. The figure that most resembles *Parkinsoni*, and which he calls *Parkinsoni* of Sowerby, he re-named *Reussii*, distinguishing it as having " wider and shorter whorls, with the ribs multiplied on the last whorl, and continued to the outer edge of the wing." Geinitz, however, subsequently, in 1850, declared that *Parkinsoni* is not found in Germany, all the various forms there being distinct. Goldfuss figures a very similar form as *R. papilionacea*, Reuss, two others as *R. Reussii* and *R. megaloptera* (Verst. der Böhm. Kriede, tab. ix).

The following notices probably all refer to true *Parkinsoni*. Brongniart, 1829; Leymerie, 1842, Gault, not Lower Chalk; D'Archiac and Lesueur, 1846, figuring at the same time what appears to be a young specimen of this shell as *Littorina plicatilis*, Mém. Soc. Geol., vol. v. pl. 17. f. 8; Graves, Gault of Oise, 1874; D'Archiac, Gault of Escragnolles, Cornuel, Haute-Marne, 1851; Gras, from Isère, 1852; Renevier, Perte-du-Rhône, 1854; Cotteau, from the Yonne, 1854; Ebray, Lower Gault of Cosne, 1857; Raulin and Leymerie, Yonne, 1858; and Sæmann from the Glauconie de la Sarthe. In addition to these, this shell is *figured* by Pictet and Roux in the Moll. Foss. des Grès Verts, pl. 24, f. 25; and by Briart and Cornet, Meule-de-Bracquegnies p. 18, pl. ii. f. 4, 5, 6; fig. 4 has a wing differing from ours, but it has probably been restored; Dr. Chenu in the Man. Conch. p. 560, 1859. D'Orbigny figured *A. marginata* in the Terr. Crét. as *A. Parkinsoni*, and mentions it in the Prodrome, in which he separates the Blackdown species under the name of *R. Megæra*.

In England, Professor Edw. Forbes was, I think, the first to separate the Chalk species of Mantell from that of the Gault, in the Quart. Journ. G. S. for 1845, p. 350; Prof. Morris gives it in his Catalogue of British Fossils from Folkestone and Blackdown; and Mr. Tate described it under a sub-generic name as *Perissoptera Reussii* in the Geol. and Nat. Hist. Repert. p. 99, f. 18. *A. Robinaldina* and *A. glabra*, from the Lower Greensand, have both been confounded with this species. For the remaining references to *A. Parkinsoni*, see *A. Mantelli*.

APORRHAÏS MANTELLI, mihi. Pl. VI. Figs. 8, 9.

SYNONYM: *A. Parkinsoni*, Mant.

Description.—Shell elongated, spire composed of convex whorls, ornamented with 12 or more regular, rather oblique, transverse ribs, extending the whole breadth of the whorls. Last whorl destitute of keel. The wing is broad, angular, and quadrate, prolonged posteriorly into a point, beneath which is a deep sinus, succeeded by a broad, quadrate expansion, which expansion is also frequently prolonged into a point, parallel to the first, truncated at its outer margin. The mouth is narrow, porcellanous; the anterior canal moderately long and straight.

A. Mantelli differs from the Gault form *A. Parkinsoni* in the fewer number of ribs and their much greater relative prominence. The broad, quadrate expansion is much more truncated, angular, and pointed, both anteriorly and posteriorly.

Distribution.—It is found in the Grey Chalk of Dover, and, on the authority of Mantell and others, at Hamsey, Leacon Hill, South Downs, etc.; but the only perfect specimens I have seen have come from a bed of the Grey Chalk known as the *cast-bed*, between Dover and Folkestone. The condition in which the fossils of this bed are found is peculiar; for although casts, they are not internal moulds of the shells, but the test seems very gradually to have perished without obliterating the external markings, which remain distinct in the form of a thin deposit of sulphate (?) of iron on the mould. Many of the fossils obtained from this deposit are peculiar.

History.—It will be seen, on referring to the history of *A. Parkinsoni*, that Mantell first named the Blackdown species *Rostellaria Parkinsoni*, but that he also included the present Grey Chalk species, which bears a strong resemblance to it, under the same specific name. This shell, however, differs in several specific characters, and requires separating from the Gault form, and does not appear identical with any of the Chalk forms described by Continental authors. I have therefore named it after Mantell, who first described it.

Among British authors, Dixon, in his Geology of Sussex, p. 358, tab. xxvii. f. 31, 36, describes this shell as *A. stenoptera*, and Mr. Tate, in 1865, as *A. Parkinsoni*.

APORRHAÏS MANTELLI, *var.* SUB-TUBERCULATA, mihi. Pl. VI. Fig 10.

A form exactly resembling *A. Mantelli* in the shape of the wing and spire, excepting in the last whorl, on which the ribs are divided into two distinct rows of tubercles. The ribs on the remainder of the shell are finer, and do not quite reach to the sutures. It is a smaller shell than those from the Grey Chalk of Dover. Compare Fig. 10 and Figs. 8, 9.

Two specimens are in that part of Mr. Cunnington's collection recently purchased by the British Museum. They were found in the Chalk Marl, near Devizes.

In the present imperfect state of my knowledge of the numerous similar European forms, I have thought it only advisable to give a list of the species known and described, and to state that the pterygoid processes or wings of those mentioned below are more expanded, and are attached to a greater portion of the spire, than those just described, and are none identical with the English forms.

List of species from the Chalk figured by continental authors allied to *A. Mantelli* :—

R. acutirostris, Pusch, 1837; Geinitz, 1839.
R. gigantea, Geinitz, 1839.
R. megaloptera, Reuss.
R. papilionacea, Goldfuss, Geinitz, Reuss, etc.
R. emarginulata, Geinitz, 1850.
A. stenoptera, Goldfuss, 1843.
A. Reussi, Geinitz, 1842.
Buccinum turritum, Roemer, 1841.

Several species from Gosau may be included in this group. *R. costata* and *granulata*, Sow.; *R. digitata* and *crebricosta*, Leheli; *R. Partschi*, Leh.; *R. passer*, and several undescribed species in the Museums at Dresden, Vienna, Munich, etc. *A. glabra*, and *A. Robinaldina*, from Atherfield, must also not be omitted from the list.

EXPLANATION OF PLATE VI.

FIG. 1.—*Aporrhaïs marginata*, Gault, Folkestone. Full grown, with thickened wing. From the author's cabinet.
FIG. 2.—A young specimen showing growth of wing. From the author's cabinet.
FIG. 3.—Specimen having thin and linear ribs to the last whorl. This variety occurs in an upper bed at Folkestone. In the British Museum.
FIG. 4.—*Aporrhaïs Parkinsoni*, Folkestone. Full grown. From the author's cabinet.
FIG. 5.—A younger specimen, with immature wing. From the author's cabinet.
FIGS. 6 and 7.—Specimens from Blackdown. In the British Museum. To show variations in size and ornamentation.
FIGS. 8 and 9.—*Aporrhaïs Mantelli*, from the Grey Chalk, Folkestone. The original in the author's cabinet.
FIG. 10.—*Aporrhaïs Mantelli*, var. *sub-tuberculata*. From the Chalk Marl near Devizes. In the British Museum. Part of the spire has been left out for want of space.

(To be concluded in our next Number.)

III.—ON SOME NEW LIASSIC FOSSILS.

By RALPH TATE, Assoc. Lin. Soc., F.G.S., etc.

MR. T. BEESLEY, in a "Sketch of the Geology of the Neighbourhood of Banbury," 2nd edit., 1873, published a very extensive list of Liassic fossils, and having been honoured by the loan of many of them, the majority in an excellent state of preservation, I beg to record the presence of a few interesting forms, and to describe some new species. The following include some species that have not been hitherto noticed, and others that are little known in Britain :—*Notidanus amalthei*, Oppel; *Pleurotomaria mirabilis*, Deslong.; *Trochus Ægion*, D'Orb.; *Phasianella turbinata*, D'Orb.; *Pleurotomaria helicinoides*, Röm.; *Onustus heliacus*, D'Orb.; *Limea cristata*, Dumort.; *Mytilus Aviothensis*, Buvignier; *Spiriferina oxygona*, Bur.; and *Siderolites Schloenbachii*, Brauns. The last is placed among the Foraminifera by its describer, but it seems to me to be a *Neurofungia*.

AMMONITES ACUTUS, spec. nov.

Syn. { FALCIFEREN AMMONIT, Quenstedt's Jura, t. 22, f. 31.
AM. SERPENTINUS, Beesley, op. cit. p. 10, 1873.

This species has some resemblance to, but is obviously distinct from, *A. serpentinus.* No specific name has yet been applied to the species represented by Quenstedt's figure, though one or two authors have sought to include it under certain new species described by them. *A. pseudo-radians,* Reynes, makes a near approach to it, but the whorls are more embracing in the present species, which I call *A. acutus,* on account of its sharp, elevated keel. As Sowerby's *A. acutus* is now recognized as belonging to *A. margaritatus,* the specific name is free to be re-applied.

It is not uncommon in the rock-bed of the Middle Lias (Zone of *Ammonites spinatus*) near Banbury: Quenstedt quotes it from the same horizon in Wurtemberg.

PATELLA BEESLEYI, spec. nov.

Shell thin, subpellucid, conical; ornamented with concentric rugose folds, which are finely serrated on the posterior side by radial striæ; the summit is obtuse, and placed at the anterior fourth of the shell; the base is entire, oval, narrow, and abrupt anteriorly, broad and depressed posteriorly. Diameters 12, and 9-20ths of an inch, height 3-20ths. It is allied to *P. Hennocqui,* Terqm., from the Lower Lias of Lorraine.

Zone of *Ammonites capricornus,* Banbury (spec. unique).

All the hitherto-known *Patellæ* in the European Lias are from the Lower Lias, and in addition to *P. Beesleyi,* another species remains to be added to the Medio-Liassic representatives of the genus; it is the following:

PATELLA GRATANS, spec. nov.

Shell ovate, conical, apex acute nearly central; ornamented with faint radiating lines and concentric squamose costulæ; base flat, margin entire.

Diameters 7-20ths and 5·5-20ths of an inch; height 3-20ths.

Zone of *Ammonites spinatus,* Uley, Gloucestershire (1 specimen, Coll. Geol. Surv.).

PURPURINA ARMATA, spec. nov.

Shell conoidal, spire pointed; whorls subquadrate, step-like; ornamented with thick transverse ribs (12 in the last whorl), subspinous on the keel, and with three thick longitudinal costæ on the posterior part, and on the front of each whorl; base rounded, oblique, with a few prominent concentric folds.

Length $\frac{3}{4}$ inch, diameter little more than $\frac{1}{2}$ inch.

P. armata is more conical than the majority of the congeneric forms, but has some affinity with *P. Bellona.* It is not to be confounded with *P. ornatissima,* Moore, the only other Liassic species of the genus, as restricted by Deslongchamps, but greatly resembles in shape and ornamentation *Brachytrema Wrightii,* Cotteau, of the Middle Oolite.

Upper Lias, near Banbury (1 example).

TROCHUS TIARELLUS, spec. nov.

Shell conical, of five and a half whorls, separated by a deep suture; apical whorls flat, anterior ones slightly concave, ornamented with oblique costæ, and longitudinal striæ. Last whorl carinated; the transverse ribs are subnodulose at the suture, have a backward direction, and vanish before reaching the keel, but which are continued on to the base of the shell as oblique striæ. Base convex, concentrically striated, imperforate, aperture ovate, columella twisted.

Height $\frac{1}{4}$ inch, breadth $\frac{1}{5}$ inch, height of last whorl $\frac{1}{8}$ inch.

Zone of *Ammonites spinatus*, King's Sutton (1 example).

CERITHIUM CONFUSUM, spec. nov.

Shell elongate-conical, whorls (15) depressed, suture channelled; ornamented with ten longitudinal costæ, and transverse granulated striæ. The five posterior costæ are granulated, the granulations are arranged in an oblique series, and continued as striæ with a forward direction on the remainder of the breadth of the whorl; the two anterior costæ are also granulated, especially the one next the suture. Base oblique, with about four granulated encircling folds. Length $1\frac{1}{4}$ inch, breadth $\frac{1}{4}$ inch.

Zone of *Ammonites spinatus*, near Banbury (3 specimens).

C. confusum has some resemblance to *C. Moorei*, Tate, = *C. pyramidale*, Moore, M. and U. Lias, S. W. England, t. 4, f. 8. 1867, non *C. pyramidale*, Sow., *id.*, D'Orbigny, 1854.

CERITHIUM FERREUM, spec. nov.

Shell turriculate-elongated, polished; whorls (12) subconcave, suture linear, last whorl with longitudinal depressed costulæ, smaller and more depressed towards the suture; the posterior whorls are, in addition, ornamented with flexuous ribs, which originate at the posterior suture, and fade off at about the middle of the whorl. Base with eight concentric costulæ; aperture oval-oblong; peristome continuous; canal short, lateral.

Length 7–10ths inch, breadth 7–40ths inch. It is related to *C. quadrilineatum*, Röm., and *C. costulatum*, Deslong.

Zone of *Ammonites spinatus*, King's Sutton (4 examples).

SPIROPORA LIASSICA, spec. nov.

Syn. { SPIROPORA sp., MM. Deslongchamps, Bull. Soc. Linné, Normandie, vol. iii. p. 58, 1859.
CERIOPORA sp., Beesley, loc. cit., p. 10, 1873. }

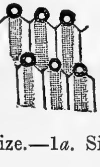
1   1*a*

FIG. 1.—*Spiropora Liassica*, Tate, nat. size.—1*a*. Six of the cellules magnified.

Polypary small, stout, composed of [flattened or] cylindrical dichotomous branches; covered by rather close obliquely annular rows of exsert cellules, between which is a longitudinal rib. The cellules are about twelve in a series, and are separated by spaces nearly equal in breadth to the cellules.

The rarity of Polyzoa in the English Lias increases the interest to be attached to the present species, which it claims as being the precursor of its kind. It was noticed by the Messieurs Deslongchamps, who obtained a single example, but in too bad state of preservation for figuring or describing, from the *Leptœna*-bed at May; whence I have a very good specimen which has served for the foregoing description. Mr. Beesley collected several specimens from the *Spinatus*-beds at King's Sutton; some of them are flattened, almost foliaceous; but they are not entitled to specific distinction.

IV.—Contributions to the Study of Volcanos.

By J. W. Judd, F.G.S.

The Lipari Islands—Stromboli.

(*Continued from page* 152.)

In the months of May, June, and October, 1855, and again in July, 1856, Stromboli was visited by M. C. Ste.-Claire Deville. He fully confirms the great variations in the intensity of the explosions of the volcano. On the night of the 14th of October, M. Deville, profiting by a favourable condition of the wind, was able to examine the bottom of the crater. He found three open vents within it; one of these did not project any solid matter, but the vapours above it reflected a glowing light of varying intensity; the other two discharged stones with explosive outbursts. The largest of these mouths was in the midst of a little cone of scoriæ, near the centre of the crater, and it gave rise to an irregular succession of detonations, interrupted at intervals of about 15 minutes by explosions, producing magnificent "sheaves" of incandescent stones: the other opening was at the north-west angle of the crater, and gave rise to less violent explosions at intervals of about four minutes. On the upper part of the Sciarra, Deville saw, whenever the vapour drifted aside, an appearance, concerning which he was in doubt, whether it should be referred to a stream of lava, or an open fissure filled with incandescent material.

On the 2nd of July, 1856, M. Deville, accompanied by M. Bornemann, again ascended to the crater of Stromboli, and they record a most striking change in the condition of the crater. One very violent outburst took place, apparently from the mouth at the north-western side of the crater, but during the two days following only a series of very insignificant explosions occurred, sometimes almost uninterruptedly. They gave rise to only a feeble glow of light, and took place sometimes at the rate of three or four within the space of a minute.

M. Deville on several occasions carefully timed the intervals between the consecutive explosions in the crater as seen from the outside. On the night of the 31st of May, 1855, as witnessed from the sea, they were 15–3–15–17–11–15–16–3–4–8–16–4–5–3 minutes. On the night of the 14th October in the same year, as seen from the edge of the crater, they were 15–4–3–12–11–14–13–2–3–6–6–3 minutes. Of five successive intervals, noted in daylight on the 13th June, 1855, the longest was 21 minutes and the shortest 4 minutes.

In the latter part of 1864, Mr. Robert Mallet and Colonel Yule ascended to the crater of Stromboli. They were unable to see the floor on account of vapours which issued from the bottom and sides. Although the actual vents were not visible, Mr. Mallet was led to infer that the explosions took place from different points of its bottom, and he found the intervals between them to vary between 30 or even 40 minutes and 2 minutes. Each outburst "was preceded by several distinct low detonations, with intervals between each of from 4 to 5 seconds to as much as 80 seconds: these, though of a far deeper tone, greatly resembled the cracking noises that are heard when steam is blown into the water of a locomotive tender for the purpose of heating it." The outbursts themselves are described as not being quite instantaneous in character, but as beginning with a hollow growl and clattering sound increasing to a roar, which endures for a few seconds to a minute or two, and then rapidly declines. Both the preliminary detonations and the shock of the outburst are stated to have sensibly shaken the ground on which the observers stood.

During the eruption of Etna in the beginning of 1865, Stromboli is said by the inhabitants of the island to have been in a state of extraordinary activity. The explosions were more violent than usual, liquid lava was emitted from the crater, and showers of ashes during several days covered the entire island. At the time when M. F. Fouqué visited the volcano, in the summer of the same year, it had, however, resumed its ordinary condition of subdued eruption.

In 1867, M. Jannsen made some spectroscopic examinations of the ignited gases within the crater of Stromboli; but his observations on this volcano appear to have been attended with considerable difficulty. In 1870, Dr. Julius Schmidt made some observations on the condition of the volcano.

On the 18th of April, 1874, after having on preceding days examined the lower portions of the mountain, I climbed up to the summit before sunrise, and descending thence a few hundred feet, spent five hours in examining the phenomena from near the edge of the crater. On this occasion, as in my other journeys in the Lipari Islands and Sicily, I was accompanied by Signor Pasquale Franco, of the University of Naples. During the ascent, I had a lateral view of the crater during one of the explosions, as seen from the side of the Schiarra; of this explosion I made the accompanying sketch (Fig. 12). On the north side of the crater a fissure is seen thickly encrusted with yellow salts, which is called the "Filo-della-solfre." The explosions appeared to me not to take place from the centre of the crater, but from near its north-western side.

Like all who have, during at least ten years past, examined the crater of Stromboli, I was prevented from seeing the interesting operations taking place at its bottom by the thick clouds of vapour, which were poured forth by innumerable fumaroles both within and around it. Seated near it, however, and occasionally getting glimpses of its interior when the wind drifted aside the heavy cloud of vapour, I was able to note the following phenomena.

A succession of loud snorting puffs like those of a high-pressure steam-engine, but quite destitute of their regularly rhythmical

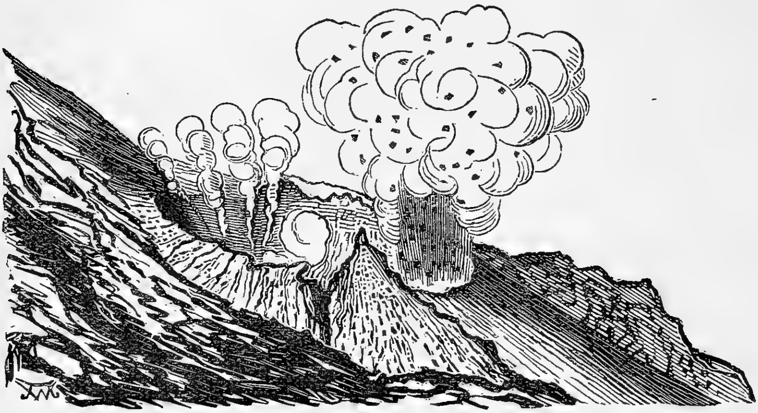


Fig. 12.—View of the active crater of Stromboli from the north side of the Sciarra, during an explosion.

character, were very distinctly audible. These were emitted continuously, but with most striking variations in their intensity, duration, and rate of succession. A long succession of slight short puffs would be followed by one or more longer and much louder ones. I attempted in my note-book to record the succession of these by means of lines, the length of which should represent the duration of the puff, and its thickness the intensity. I give the following as examples of these :—

and

Sometimes the snorting sound would die away almost entirely, but at others it would burst out again suddenly with a loud series of sudden puffs.

From time to time violent outbursts of steam would take place at the bottom of the crater, carrying aloft fragments of lava, scoriæ, and ashes. So far as I was able to judge, these outbursts were not preceded by warnings of any kind, but occurred with the greatest suddenness. These outbursts certainly seemed to me to be quite independent of the puffing sounds, and, I can scarcely doubt, took place from a different mouth. The sound which accompanied the explosions was always sudden, but by no means violent. It did not in the least resemble the report of a cannon, but rather the rushing sound which is heard when a large number of rockets are discharged simultaneously. The noise of the falling fragments, falling upon and rattling down the sides of the crater and the Sciarra a few seconds after, was quite as striking as that of the explosion itself.

After watching the explosions for a considerable period, both on this and several other occasions, I found myself quite unable to correlate, in any way, the force and duration of the explosions with the intervals between them. I feel strongly led towards the conclusion that there were at least two orifices within the crater discharging independently. On several occasions two explosions were so close to one another, that I can hardly believe they took place from the same mouth. The observations of MM. Abich, de Quatrefages and Deville lend great support to this supposition.

I was informed by very intelligent residents in the island, namely the priest and his brother, whom I closely questioned upon the subject, that the most striking variations occur in the condition of the volcano. Sometimes, in summer, intervals of considerable length, occasionally extending to two hours, were declared to pass without any explosion. During the winter, however, it was said very violent outbursts sometimes take place. Large stones fall in the cultivated and inhabited portions of the island (and some of these I was shown); streams of lava flow down the Sciarra into the sea; and dead fish in great numbers are found floating around the island.

The succession of explosions which I witnessed on different occasions may thus be represented, using M for an outburst of moderate intensity, v for a violent, and V for an excessively violent one; s stands for slight, and S for very slight explosions. The intervals between them are given in minutes :—

On the 18th of April, 1874, commencing at 7·13 A.M.

M $6\frac{1}{2}$,—M $4\frac{3}{4}$,—v 16,—M 4,—v 11,—s $2\frac{1}{4}$,—s $2\frac{3}{4}$,—S $5\frac{1}{4}$,—V $6\frac{3}{4}$, v $3\frac{3}{4}$,—M $7\frac{3}{4}$,—v $1\frac{1}{2}$,—S 4,—M 9,—s $\frac{1}{2}$,—s $2\frac{1}{2}$,—M 3,—M $1\frac{3}{4}$,—s $2\frac{1}{4}$, S 4,—M $\frac{3}{4}$,—M $5\frac{1}{4}$,—M 4,—s $1\frac{3}{4}$,—S $\frac{3}{4}$,—M 1,—S $5\frac{1}{2}$,—M $3\frac{1}{2}$,— s $10\frac{1}{2}$,—M 5,—v 5,—M $1\frac{1}{2}$,—v $18\frac{1}{2}$,—V $2\frac{1}{4}$,—M $2\frac{1}{4}$,—M $8\frac{3}{4}$,—V 5, M $5\frac{1}{2}$,—s $2\frac{1}{2}$,—S $6\frac{1}{2}$,—S $1\frac{1}{4}$,—s $1\frac{1}{4}$,—S $6\frac{1}{4}$,—v $3\frac{3}{4}$,—M $3\frac{1}{2}$,—s $1\frac{1}{2}$,— S 8,—s $\frac{1}{2}$,—S 2,—s $2\frac{1}{2}$,—s 6,—M 3,—s 4,—v $1\frac{3}{4}$,—s $5\frac{1}{2}$,—V.

On the 24th of April, 1874, beginning at 4·56 A.M.

V $10\frac{1}{4}$,—s $5\frac{1}{4}$,—s $1\frac{3}{4}$,—v.

On the 25th of April, beginning at 7·8 P.M.

v 30,—s 1,—V $3\frac{1}{2}$,—v 2,—S 1,—s $\frac{1}{2}$,—v $3\frac{1}{2}$,—M $2\frac{1}{2}$,—M $4\frac{1}{2}$.— M 2,—M $1\frac{1}{2}$,—S 1,—v $1\frac{1}{2}$,—M $8\frac{1}{2}$,—V $2\frac{3}{4}$,—S $4\frac{1}{4}$,—s 2,—v $2\frac{1}{2}$,— s $\frac{1}{2}$,—M 2,—V 5,—s 3,—M $1\frac{1}{2}$,—V 3,—M 6,—V 10,—M $1\frac{1}{2}$,—M 5, —V $1\frac{1}{2}$,—s $3\frac{1}{2}$,—M 3,— S$3\frac{1}{2}$.

Having thus given a *résumé* of the observations which have been made on the very interesting volcano of Stromboli during more than a hundred years, we may proceed to summarize those facts concerning its general features, and the nature of the operations going on within it, which these observations combine to establish.

With respect to the heights of the various parts of the mountain, the position and relations of its crater, and the depth of the sea around it, Mr. Robert Mallet has lately cast doubt on the accuracy of the statements of previous observers, and has published a series of "hypsometric measurements," which were made by him in 1864, "by means of a single aneroid," and of soundings made in positions which were "guessed" by himself and a friend. On the basis of these corrected measurements, Mr. Mallet has put forward a very novel and startling theory, namely,—that Stromboli is not an ordinary volcano, as every previous observer had supposed, but a singular combination of a geyser and a volcano!

It is certainly to be regretted, not only on Mr. Mallet's own account, but for the sake of the credit of British science, that, during the ten years which elapsed between his obtaining these observations and his publication of the extraordinary theory which he has founded upon them, no attempt seems to have been made by this author, either to verify or check his measurements, although the most ample means existed, in numerous official publications, for so doing.

In order to give a distinct idea of the true relations of the different parts of the volcano, I have constructed a section (see Fig. 13) on the natural scale, passing from N.W.

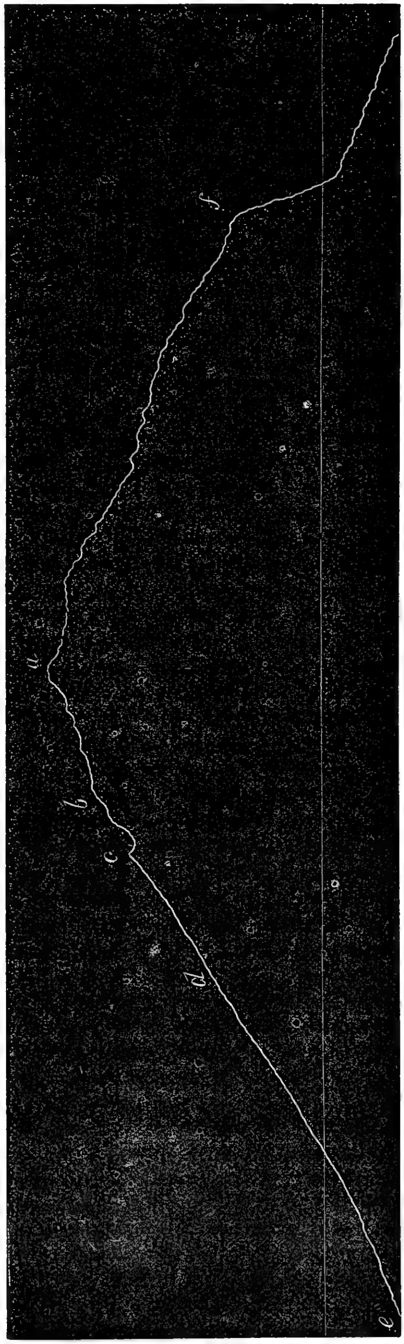


FIG. 13.—Section through the Island of Stromboli (scale 1 in 25,000). *a.* Highest summit of mountain. *b.* Point overlooking the crater. *c.* Cratère del Fossa. *d.* Sciarra del Fuoco. *e.* Steep submarine slope, forming its continuation. *f.* Steep cliffs of the Punta dell' Omo.

to S.E., through the Sciarra del Fuoco, the summit of the mountain, and the Punta dell' Omo. This section is based on the large map constructed by the Italian Instituto Topografico Militare, and on the splendid Chart of the Lipari Islands issued by the French Government, from the surveys made by MM. Darondeau, Gaussin, Boutroux, Manen, Larousse, and Vidalin in 1857 and 1858. In all its main details, too, the accuracy of this section is confirmed by the English and Neapolitan Admiralty Charts, and by the observations of Abich, Hoffmann, and other geologists.

Both of the official documents referred to give the height of the mountain as over 3000 feet. The elevation of the ridge overlooking the crater, which Mr. Mallet states as only 1200 feet, has been shown by repeated measurements, which I can myself confirm, as being only about 600 below the summit, or at least 2400 feet, that is, *twice* the amount given by Mr. Mallet!

The outer lip of the crater (or, in other words, the top of the inclined plane of the Sciarra del Fuoco) and the bottom of the crater are points quite inaccessible to the observer; but there nevertheless exist means of estimating their true elevation above the sea-level. Abich, who under-estimated the height of the summit of the mountain by about 200 feet, on the supposition that the inclination of the Sciarra was only 30°, fixed this point at 1645 feet above the sea-level. Mr. Mallet measured the slope of the Sciarra with the clinometer as from 34° to 36° with the horizontal, and I am convinced from my own observations that 35° is about a fair average. The exact position of the crater and its relation to the other parts of the island being given in the map of the Italian Government, we are thereby able to fix the elevation of this point as a little over 2200 feet. Mr. Mallet states it to be only 600 feet! Calculating from the positions of the several points as given on the map, this would make the slope of the Sciarra only 11°, which is not only quite at variance with Mr. Mallet's own measurements, but would be at once rejected by every one who had seen either the island itself or any drawing of it. With respect to the elevation of the bottom of the crater, which is probably liable to constant variation within small limits, I am in the same predicament as Mr. Mallet, having never succeeded in getting a sight of the crater-floor, owing to the clouds of vapour proceeding from the fumaroles. Several accurate observers who have seen it, however, declare it to be situated only a short distance below the outer lip. The estimate of at least 2000 feet, which most authors have given for the elevation of the bottom of the crater of Stromboli, we must, therefore, regard as certainly *below* the truth, while Mr. Mallet's statement that it "cannot be more than 300, or at most 400 feet, above the level of the sea," is altogether erroneous.

Lastly, Mr. Mallet's assertion that the Admiralty Chart indicates "that for some miles in the offing here the Mediterranean does not exceed 100 fathoms in depth," is to me simply inexplicable—since the English, French and Neapolitan Admiralty Charts all give numerous soundings of more than twice that amount, within a mile of the shores of Stromboli, while within a few miles of the island soundings of more than 700 fathoms occur.

Mr. Mallet's hypothesis of "the Mechanism of Stromboli" is based entirely on these grossly inaccurate "measurements;" and as it has already been criticized by Mr. Scrope in the pages of the Geological Magazine, I am spared the necessity of dwelling longer upon this painful subject.

Nearly every observer who has studied the phenomena presented by Stromboli, has been convinced that the permanent character of its action is connected with the existence of the steep slope of the Sciarra, which enables the ejected materials, sooner or later, to roll down into the sea, instead of accumulating around the vent and stifling its action for a time, only to lead to more violent paroxysms. The formation of the present crater, with the steep slope of the Sciarra leading down from it to the sea, was ascribed by Mr. Scrope in 1825 to some violent paroxysm, which had destroyed a large portion of that side of the mountain. This explanation is accepted by Hoffmann, and nearly every other geologist who has examined the question. Abich, indeed, not unjustly compares the destruction of one side of the mountain and the formation of an eruptive centre at a lower level, to the catastrophe which in the year 79 A.D. resulted in the blowing away of one side of the ancient Somma, and the rise of the modern cone of Vesuvius in its midst.

Let us now proceed to notice the character of the operations going on within this still active crater of Stromboli. These operations appear to have been, during the last 2000 years at least, of a comparatively *moderate* character. We have no record or tradition of the activity of the mountain becoming so violent as, in the case of Vulcano, to drive away the inhabitants, who have formed settlements (having a population in 1871 of 1,999) on the lower slopes of the island, at a distance of two miles from the crater. On the other hand, that the action is sometimes so energetic as to shake the whole island, to cover every part of it with showers of ashes, and to result in outflows of lava from the active crater and other portions of the flanks of the volcano, we have the clearest evidence.

With regard to the condition of the interior of the crater of Stromboli, we have also proofs of the occurrence of continual changes, similar to those which have been noticed in Vesuvius, and all other volcanos that have been systematically studied. That the bottom of the crater is a thin and variable crust, which covers a mass of incandescent and liquefied material, and that this heated mass communicates with the atmosphere by openings in the crust, which are continually changing in number, size, form, and position, no one can doubt who reads the account of the appearances presented by the interior of the crater at different periods. According to the nature of these openings, and their relations to the incandescent fluid mass beneath, they are found quietly giving off jets of vapour and gas,—violently discharging columns of steam,—permitting liquid lava to rise and fall within them, and to be dispersed by sudden and intermittent explosions,—or giving origin to small streams of lava. That, during the more violent eruptions, when the constant red glow above the mountain testifies to the existence of incandescent materials within the crater, and when abundant streams of lava flow down into the sea, the solidified crust forming the bottom of the crater is temporarily destroyed, we can scarcely doubt. Stromboli, indeed, appears to present, on a smaller scale, precisely the same characters with those seen in the volcano of the Ile de Bourbon, as described by Bory de St.-Vincent, and in the crater of Kilauea in Hawaii, as described by Dana and other observers.

That the more violent states of activity in Stromboli coincide with the winter seasons and stormy weather, and its periods of comparative repose occur during the calms of summer, is established, not only by the universal testimony of the inhabitants, but, as the foregoing accounts will show, by the actual observations of many competent authorities.

The very graphic accounts which we have quoted of the appearances presented by the liquid lava as seen rising and falling in the vent, agitated by whirling movements, and swelling up into vast bubbles which suddenly burst and give off clouds of vapour, are strongly suggestive of the same conditions as exist when any liquid or viscous material is heated, especially in a deep and narrow vessel, over the fire. In such cases, as vapour is being disengaged *within* the heated mass, the whole is kept in violent agitation; the small bubbles collecting into large ones force the whole mass upwards, and if the heat be not moderated, these bubbles burst on reaching the surface, and scatter the materials with explosive violence. That the lava of volcanos is a fluid mass containing imprisoned water, which, as it is relieved from pressure, flashes into steam, is now recognized by all geologists.

That the barometrical condition of the atmosphere must exercise a powerful influence on such a series of operations, as are seen to be going on within the crater of Stromboli, few probably would be bold enough to deny. Whether the notion, which, as we have seen, has prevailed in these islands from the earliest times concerning which history or tradition affords us any record, namely, that the state of the volcano enables the observer to *predict* the changes of weather, is a totally different question. Until we are able to appeal to an accurate series of meteorological observations, carried on concurrently with others on the condition of the volcano, the question must remain an open one. But every careful observer will willingly subscribe to the words of Spallanzani on the subject: "I should think myself justly to incur the imputation of rashness, should I venture to deny these facts, without having sufficient reason so to do; especially as they are so precise, so circumstantial, and said to have been observed upon the spot."

Stromboli consists, as we have already seen, of an older central cone, composed of trachytes, coated on all sides by thick masses of more recent basaltic lavas and agglomerates (see pp. 11 and 61). As in the case of Vesuvius and many other volcanos, very beautifully crystallized minerals (especially augite), which must have been formed *within* the vent, are ejected from its crater.

In bringing these sketches of the Lipari Islands to a close, I may notice an interesting circumstance, to which my attention has been drawn by Professor Suess, of Vienna. That geologist has recently published an important memoir, entitled "Die Erdbeben des südlichen Italien," and he has been good enough to point out to me that the lines of fissure, which, from a study of the seismic phenomena of Sicily and Calabria, he has inferred traverse those districts, point, like those which I have determined on totally different evidence, to the central submerged tract of the Lipari Islands.

V.—A Chapter in the History of Meteorites.

By Walter Flight, D.Sc., F.G.S.,
Of the Department of Mineralogy, British Museum;
Assistant Examiner in Chemistry, University of London.

(*Continued from page* 163.)

1871. March 24th. 2 a.m. (local time).—Urbino, Province of Urbino and Pesaro, Italy.[1]

A brilliant meteor was observed by Serpieri at the Observatory of Urbino, which left a persistent streak. It was attended by an explosion.

1871. March 24th. 4·25 a.m. (local time).—Volpeglino, Piedmont, Italy.[2]

This meteor is described in a Turin newspaper by F. Denza. Its apparent course was from α Cygni across α Andromedæ to near ζ Piscium. The nucleus had a diameter of 25′. The colour was of a brilliant white, and it left a very persistent ruddy streak along its whole course. It burst with a violent detonation, which was heard about half a minute after its disappearance.

1871. April 12th. 8·15 p.m. (local time).—Lodi, Moncalieri, Piedmont, Italy.[3]

A very large and brilliant meteor traversed the heavens from 111 + 7 to 105 + 2, and burst with a loud detonation, which was heard in houses with closed doors. The account of this meteor is communicated by F. Denza, of the Observatory of Moncalieri.

1871, Spring of.—Roda, Province of Huesca, Spain.[4]

The exact date of the fall of this meteorite is not given, but it is stated to have occurred during the spring of 1871, at a spot two kilometres from Roda. Two fragments, in the possession of Pisani, weigh about 200 grammes, and appear to have formed the half of a stone which was of the size of a fist. It is covered with a black crust, which is continuous and brilliant in places where this species of lustrous varnish has run. The interior is ashey-grey, with greenish

[1] *Brit. Assoc. Report*, 1871. Obs. Luminous Meteors, 37.
[2] *Brit. Assoc. Report*, 1871. Obs. Luminous Meteors, 36.
[3] *Brit. Assoc. Report*, 1871. Obs. Luminous Meteors, 36.
[4] F. Pisani. *Compt. rend.*, lxxix. 1507.—G. A. Daubrée. *Compt. rend.*, lxxix. 1509.

grains resembling peridot (some several millimetres in diameter) scattered throughout the mass. The grey surface is, however, not of a uniform tint, but presents two irregularly shaped areas, one being grey, the other yellowish-grey. The stone is very friable, and has no action of the magnetic needle. Before the blowpipe it is fusible, becoming black and feebly magnetic.

Only a small portion, 14·75 per cent., of the meteorite is broken up by acid, that unacted upon amounting to 85 97 per cent. Below are given, in addition to the composition of the constituents separated by acid, the results of an analysis of the minerals constituting the mass of the stone:

	SiO_2	Al_2O_3	Cr_2O_3	FeO	CaO	MgO	K_2O and Na_2O	S	
A. *Soluble.*	38·85	4·81	...	24·27	8·21	23·86	...	...	=100·00
B. *Insoluble.*	52·93	1·95	0·39	16·29	1·92	26·52	...	...	=100·00
C. *Total.*	51·51	2·30	0·34	17·04	2·31	26·61	0·80	0·40	=101·31

The soluble portion appears to be an iron olivine, mixed probably with a little anorthite; the insoluble portion consists chiefly of bronzite, or, according to Pisani, probably hypersthene, with the specific gravity of which mineral that of the meteorite more closely accords. The sulphur and the chromium are, it is presumed, present as magnetic pyrites and chromite; no nickel whatever was detected.

The yellowish-green grains were very slightly attacked by acid, only 6 per cent. being soluble in that reagent. Their composition proved to be—

Silicic acid	51·10	27·3	
Alumina	2·83	1·3	
Iron protoxide	27·70	11·1	} 14·9
Magnesia	17·20	3·8	
	98·83		

These numbers indicate, according to Pisani's view, the presence of a hypersthene rather than a bronzite, a hypersthene richer in iron than that of Farsund, Norway. The ratio of iron oxide to magnesia is the same as that in the bronzites of the Hainholz, Shalka, Borkut and several other meteorites.

On some grains of this mineral a well-marked cleavage was distinguished along one direction; in others a disposition to cleave along a second direction was remarked; on examining such fragments in the polarizing microscope, however, one of the optic axes was almost always seen, while the other is invisible. The angle of the optic axes, as measured in oil, was approximately determined, making $2H=104^\circ$. The bisectrix is negative; but whether it was the acute or obtuse bisectrix, was not determined.

This meteorite is remarkable for containing no metallic iron, and a very large proportion of bronzite or hypersthene.

Daubrée, during an examination of microscopic sections, noted many characters which favour the assumption that the chief constituent of this meteorite is bronzite rather than hypersthene. Such are: the absence of dichroism, the frequent occurrence of the right angle in the contour of the crystals, and the fineness of the striæ, peculiar to bronzite. When magnified 800 diameters, most of the crystals are found to enclose yellowish-brown rarely translucent matter, with very varied contour, and occasionally with a crystalline form, that of a modified oblique prism, which is that of pyroxene. They are ranged in rectilinear series, which are not always orientated parallel to the axes of the crystal. Here and there, adhering to the crystals, a brown vitreous substance, which is without action on polarized light, is seen; and in it occur cavities of relatively large dimensions, closely resembling those usually found in basaltic rocks. The Roda meteorite, with the single exception that it contains no iron, bears a great likeness to the meteorite of Lodran (1868, October 1st), and establishes a new link between cosmical rocks and those belonging to our planet. If, says Daubrée, we were to refuse to admit the testimony of those persons who affirm that they witnessed the fall of this fragment of rock, the characters of its crust would fully attest its cosmical origin.

1871. November. Montereau, Seine-et-Marne, France.[1]

"It is stated that a meteorite, weighing 127lbs., lately fell near Montereau. It came from the east, and burst with a loud explosion, emitting a bright blue light. It is an irregular spheroid, and is black (on the outer surface only?). It is to be sent to the Academy of Sciences." No more recent information respecting this meteorite has reached me.

1871. December 10th. 1·30 p.m. Gœmorœh, etc., near Bandong, Java.[2]

Three strange explosions were heard, and six stones were found. The largest, weighing 8 kilog., fell in a rice-field in the village of Gœmorœh, and penetrated the soil obliquely to the depth of one metre. The second, 2·24 kilog. in weight, and a third, weighing 0·68 kilog., fell in a rice-field about 2200 metres S.W. of Babakan Djattie, and 1500 metres from Tjignelling, or 3700 metres from the spot where the first stone struck the ground. The three remaining stones weighed in all 150 grammes.

The stone the second in size, now in the Paris collection, is an irregular block, with rounded edges. It is completely enveloped in a dull black crust, and the natural surface exhibits numerous cavities of different size, which bear a great resemblance to those produced on quartzite by exposing it to the oxy-hydrogen flame.[3] A fresh fracture is grey, and inclosed in the silicate forming the greater portion of the stones are three kinds of granules, which have metallic lustre: the one, of an iron grey, which is at once identified as nickel-iron; a second, of a bronze-yellow, which often possesses a blue or yellow tint, is troilite; and a third, black and insoluble, is chromite. The siliceous portion, when examined under the microscope,

[1] *Nature*, November 30, 1871.—R. P. Greg. *Brit. Assoc. Report*, 1872, 79.
[2] G. A. Daubrée and R. Everwijn. *Compt. rend.*, lxxv. 1676.
[3] *Annales des Mines*, xix. (1869), 29.

was found to be made up of transparent, much-broken grains, which are, throughout, crystalline.

The stone was examined in Java by Dr. Vlaanderen, who found it to have the specific gravity 3·519, and the following composition:

	SiO_2	Al_2O_3	FeO	MnO	MgO	CaO	K_2O	Na_2O	Fe	Ni	Co	S	Chromite.	
A. *Soluble.*	28·669	2·377	28·036	0·199	21·290	0·498	1·479	1·164	8·227	1·712	0·233	3·540	...	= 97·424
B. *Insoluble.*	51·218	6·352	10·796	trace	13·633	1·908	0·452	3·741	...	...	...	...	11·074	= 99·174

The analyst's method of grouping these constituents shows the meteorite to have the following mineralogical composition:

Olivine	47·26
Augite	20·98
Felspar	17·00
Nickel-iron	2·81
Troilite	5·44
Chromite	4·41
	97·90

If we assume that the iron oxide in the insoluble portion of this meteorite, which is stated in Vlaanderen's analytical results to be in the state of peroxide, to be, as is more probable, in the form of protoxide, this portion of the stone appears to consist of a bronzite, in which Fe : Mg is as 1 : 1, and a felspar with the oxygen ratios of $RO : R_2O_3 : SiO_2$ as 1·04 : 2·96 : 11·6 or those of an albite or orthoclase. About 60 per cent. of the minerals in this meteorite are broken up by acid, the remaining 40 per cent. withstanding its action.

Meteoric Irons found 1870 or 1871. San Gregorio, etc., Bolson de Mapimi, Mexico.[1]

With the object of fixing with greater precision the geographical position of the meteoric masses that have from time to time been met with on the Mexican Desert, Dr. Lawrence Smith communicated this paper to the *Amer. Jour. Science.* There were already known the Cohahuila meteorite of 1854 (No. 1); the Cohahuila meteorite of 1868 (No. 2); the Chihuahua iron of 1854 (No. 3), still at the *Hacienda de Conception*, weighing about 4000lbs.; and the Tucson iron (No. 4), found in 1854 on the north side of the Rio Grande; it is in the form of a ring, and weighs from two to three thousand pounds. Another mass (No. 5) has since been heard of on the western border of the Mexican Desert, which from its locality has been named the *San Gregorio Meteoric Iron.*[2] It measures 6 feet 6 inches in length, is 5 feet 6 inches high, and 4 feet thick at the base, and is in the form of a sofa. On one part of its surface the date "1821"[3] has been cut with a chisel, and above it stands the inscription: "*Solo dios con su poder este fierro destruirá, porque*

[1] J. L. Smith. *Amer. Jour. Sc.*, 1871, 335. See also H. J. Burkart. *Neues Jahr. Min.*, 1871, 853. J. Urgindi. *Amer. Jour. Sc.*, 1872, iii. 209.

[2] This is probably the meteoric iron of which earlier mention is made by W. H. Hardy in his *Travels in the Interior of Mexico in* 1825–1828, London, 1829, 481.

[3] Burkart gives the date 1828.

en el mundo no habra quien lo pueda deshacer." (God only with his might this iron will destroy, for in the world is no one able to break it in pieces.) It lies within the inclosure of a hacienda, having been hauled to the ranch years ago by the Spaniards, who, so the story goes, thought to use it for the manufacture of farm implements. Its weight is estimated to be about five tons. An examination of a fragment showed it to consist of:

Iron = 95·01; Nickel = 4·22; Cobalt = 0·51; Phosphorus = 0·08; Copper = Trace; Total = 99·82.

Still more recently we have news of the discovery, in the central portion of the desert, of a meteorite (No. 6) larger than any previously found in that region. It should be stated here, that in addition to meteorites No. 3 and No. 4, Juan Urgindi mentions other larger ones at Chupaderos, 20 leagues N.W. of No. 4. L. Smith's paper is illustrated with a little map indicating the relative position of these masses. He is of opinion that they are the result of two falls. The Tucson iron (also called the *Signet meteorite* and the *Ainsa meteorite*) he finds to possess characters which distinguish it from the other five. The latter probably fell at an epoch far remote, moving from N.E. to S.W. during their descent. Nos. 1 and 2 fell first, 85 miles apart. The distances between the larger masses are—from No. 2 to No. 6, 135 miles; from No. 6 to No. 5, 165 miles; and from No. 5 to No. 3, about 90 miles.

In a paper on some of the meteoric irons of Mexico, D. J. Correjo (*La Naturaleza, Periodico cientifico de la Sociedad Mexicana de Historia Natural*, i. 252) reviews what has been published about the Mexican irons, and gives some additional facts respecting them. A recent number of the journal contains an indignant protest of the Society with reference to the destruction of the large meteorite, called "*The Descubridora*," ordered by the Mexican Society of Geography and Statistics (*Amer. Jour. Sc.*, vii. 75).

1871.—Victoria, Saskatchewan River. [Lat. 53° 45′ N., Long. 111° 30′ W.].[1]

In 1870 Captain Butler received orders from Lieut.-Governor Archibald, of Manitoba, to proceed on a mission to the Saskatchewan. While returning from the Far West he passed, on the 25th December, 1871, through the village of Victoria, which lies on the North Branch of the river, about midway between Fort Edmonton and Fort Pitt, and was shown, in the farmyard of the mission-house of that Station, a curious block of metal of immense weight. It was rugged, deeply indented, and polished on the edges by wear and friction. Longer than any man could say, it had lain on the summit of a hill out on the southern prairies. It had been a medicine-stone of surpassing virtue among the Indians far and wide, and no tribe, or member of a tribe, would pass in the neighbourhood without visiting this great medicine. It was said to be increasing yearly in weight. Old men remember to have heard old men say that they

[1] *The Great Lone Land.* By W. F. Butler. London: Sampson Low. 1872. Page 304.

had, at one time, lifted it easily from the ground; now, no single man can carry it. Not very long before Captain Butler saw this meteorite, it had been removed from the hill on which it had so long rested and been brought to Victoria. When the Indians found that it had been taken away, they were loud in the expression of their regret. The old medicine-men declared that its removal would bring great misfortune, and that war, disease, and dearth of buffalo would afflict the tribes of the Saskatchewan. This was not a prophecy made after the outbreak of small-pox which was devastating the district when Captain Butler was there, for in a magazine published by the Wesleyan Society of Canada, there appears a letter from the missionary, announcing the predictions of the medicine-men a year prior to Captain Butler's visit, and concluding with an expression of thankfulness that their dismal prognostications had not been realized. A few months later, however, brought all the three evils upon the Indians. Never, probably, since the first trader had traversed their land had so many afflictions of war, famine, and plague fallen upon the Crees and the Blackfeet as during the year succeeding the removal of their Manito-stone from the lone hill-top upon which the skies had cast it.

This iron has not yet been analysed.

1871.—Rockingham Co., N. Carolina.[1]

This meteoric iron, a small specimen of which is in the Vienna collection, is described as exhibiting the ordinary lamellæ and figures. It contains iron chloride in the form of a solid green substance enclosed in the metal itself. This compound was first observed by J. L. Smith in 1852 in the Tazewell iron.

1872. July 23rd. 5·20 p.m. (Tours mean time).—Lancé and Authon, Canton of St.-Amand, Loir-et-Cher, France.[2]

An observer, reports M. De Tastes, stationed between Champigny and Brisay, in the Canton l'Ile-Bouchard, noticed during full sunshine a sudden increase of light, and raising his eyes saw a brilliant meteor, which was of a rosy orange colour, and appeared to be double, traversing the heavens with enormous velocity from S.W. to N.E. Its brilliancy suddenly increased as it separated into two luminous globes and passed out of sight in the direction of Tours. At 5·26 he heard a sharp sound, unattended by an echo. The inhabitants of the Communes Monthodon, Neuville, Châteaurenant, Beaumont-la-Ronce, and Dammarie, north of Tours, were alarmed by a tremendous explosion, which shook the houses, and a small cloud of smoke was seen in the direction of Saint-Amand, still further north. Had this happened at night instead of in an atmosphere illumined by the

[1] G. Tschermak. *Mineralog. Mitt.*, Jahrgang 1872.—J. L. Smith, *Am. Jour. Sc.*, 1874, vii. 395.

[2] *L'Union libérale*, Tours, 26th July, 1872.—*Le Loir*, 4th August, 1872.—M. De Tastes. *Compt. rend.*, lxxv. 273.—G. A. Daubrée. *Compt. rend.*, lxxv. 308 and 465.—G. A. Daubrée and M. Jolly. *Compt. rend.*, lxxv. 505.—P. de Fleury. Note sur les Météores d'origine cosmique a propos de l'Aérolithe du 23 Juillet, 1872. Blois: Imp. P. Dufresne, 1872.—G. A. Daubrée. *Compt. rend.*, lxxix. 277.—*L'Institut*, August 5th, 1874.—*La Nature*, ii. 159.

evening sun, it would not merely have attracted the notice of the few observers whose attention happened at that instant to be directed towards the sky. The meteors, though distinctly separate to many observers, were close together, and had the appearance of two candle flames proceeding horizontally at a very low elevation.[1] The loud report, which to many persons appeared to be two reports in rapid succession, was followed, as is so often the case in explosions of this kind, with "rolls of musketry," lasting 30 to 40 seconds.

A large meteorite fell in a field at La Haye de Blois, near the boundary of the commune of Lancé and Saint-Amand, and penetrated the soil to a depth of 1·4 metres. The explosion detached the hinder portion of the meteorite, which fell as one block to the ground, but which, when taken out of the hole, broke into three pieces. The anterior portion of the stone was shattered into fragments, which were scattered over a stubbled field of wheat. The owner of some cultivated land near St.-Amand was within 200 metres of the spot where it fell. It weighed altogether 47 kilog.

The trajectory of the meteorite appears to have been nearly parallel to the plane of the horizon, and the velocity is calculated to have been 640 metres per second.

A search having been instituted in the neighbourhood for other meteorites that may have fallen at the same time, a second stone, weighing 250 grammes, was found a few days later at a depth of half a metre below the surface, at a point two kilometres from the village of Pont-Loiselle in the Commune of Authon, and 12 kilometres to the S W. of the spot where the first stone fell. These two places are on the line of the trajectory of the meteor. Here, as in the case of the fall of other meteorites—for example, those of Orgueil, Tarn-et-Garonne (1864, March 14th)—the smaller stone fell first. A superficial inspection will convince the observer of the common origin and similar constitution of the two stones.

The crust of this meteorite is dull, and shows in different parts the manner in which the air has affected the heated surface during the descent. A freshly-fractured surface differs from that of a great number of meteorites in being of a very dark grey, almost black, colour, recalling that of certain basalts; it possesses a spherular structure, the grains not exceeding 1 mm. in diameter. Many are transparent and colourless, while some are of a yellowish-green; when examined in a microscopic section, these are seen to be full of flaws and to act powerfully on polarized light; here and there are particles of the bronze-like yellow hue of iron monosulphide or with metallic lustre; the latter are rarely more than $\frac{1}{2}$ mm. in diameter, and are malleable. The specific gravity is found to be 3·80; but whether this is the density of the silicate freed from nickel-iron, is not stated.

By treatment with water 0·12 per cent. of sodium chloride was extracted from a portion of this meteorite. As this salt is so common

[1] A similar instance of the division of a meteor into two during its passage through the atmosphere (which may be represented thus ——*——*) was observed at the Nicobars, 1874, May 31st, 5·30 p.m. (*Proc. Asiat. Soc. Bengal*, 1874, No. viii. 156.)

a constituent of the earth's crust, it seemed at first sight probable that it owes its presence to infiltration of water holding it in solution. The clay-like soil, however, in which the Lancé meteorite lay during three days was dry, and the vitrified crust covering the stone would preclude an infiltration of salt to its centre, from which part the fragment analysed was taken. Moreover, the absence of calcium salts, which would be expected to be associated with it, was fully established. The sodium chloride[1] of the Lancé meteorite, like the calcium chloride of the Ovifak iron (see page 122), appears beyond question to be of cosmical origin. The probable presence of what must be a trace only of copper was ascertained by spectrum analysis. No carbon was met with.

An analysis of the stone showed it to possess the following composition:

1.	Iron, as nickel-iron...	7·81
2.	Iron and other metals combined with sulphur	9·09
3.	Sulphur combined with the above metals	5·19
4.	Silicic acid	17·20
5.	Iron protoxide...	11·33
6.	Manganese protoxide	0·05
7.	Magnesia	13·86
8.	Sodium chloride	0·12
9.	Constituents not acted upon by acid	33·44
10.	Hygrometric water...	1·24
		99·33

The constituents Nos. 4, 5, 6, and 7 make up 42·44 per cent. of the stone, and are those of an olivine in which the oxygen ratio of Fe : Mg is 1 : 2, the same as that of the olivine of Chassigny, Alais, and other meteorites.

By acting upon a portion of the meteorite with hydrogen and chlorine successively at a high temperature it lost 34·98 per cent. in weight. It appears from this that the iron and manganese oxides of the olivine underwent reduction, and the water was removed by the first reagent, while the iron, nickel, and cobalt, either free or combined with sulphur, together with this sulphur, as well as the two metals forming constituents of the olivine, which, it appears, lose their oxygen when treated with hydrogen, were, one and all, removed by the action of chlorine. They amount together to 34·66 per cent. Daubrée concludes from this that the residue consists of the silicate which withstood the action of acid, together with the silicic acid and magnesia of that which gelatinizes in contact with this reagent. It is to be regretted that the composition of the insoluble portion, which constitutes one-third of the stone, and of which we are told that it consists at least of two substances, one colourless (enstatite?), and the other almost black (chromite?), has not been determined.

[1] Scheere rfound this chloride in the meteorite of Stannern (*Jour. de Phys.*, lxi., 469).—In some hailstones which fell 1871, August 20th, 11 a.m., at Zurich, and some of which weighed 12 grains, Kenngott found cubes or fragments of cubes of sodium chloride. He believed that they might have been carried by the wind from North Africa.

In its general aspect the Lancé meteorite resembles that which fell at Ornans (1868, July 11th).

Since the publication of these papers recording the fall and the examination of the Lancé stone, a letter has been addressed to M. Daubrée by M. Jolly, stating that an observer, who was at Chincé, Commune of Jaulnay, Canton of Saint-Georges, Dép. of la Vienne, heard two loud explosions, which appeared to come from the direction of Chatellerault, and a hissing noise, such as would be caused by the rapid passage of a large body through the air. This point is forty kilometres to the S.W. of that reported on by M. De Tastes.

In August, 1874, Daubrée announced the discovery of four more meteorites belonging to this fall. They weigh 3 kilog., 0·62 kilog., 0·60 kilog., and 0·30 kilog. The first had fallen near the Sablet, between Authon and Villechauve; the second and third were found about 100 metres apart at points north of Authon and about three kilometres from Prunay; and the fourth had fallen in the Commune of Authon.

1872. August 31st. 5·15 a.m. (Rome mean time).—Orvinio (formerly Canemorto), near Rome. [Lat. 42° 8′ N.; Long. 12° 26′ E.] [1]

A meteor was seen at daybreak by many observers in the provinces of Rome, Umbria, Abruzzo, and Terra di Lavoro. At first it appeared like a large star of a red colour. It increased in brilliance as it traversed the sky, in a northerly direction, leaving a white train. At a certain point it became brilliantly white, and then vanished, a luminous cloud remaining, which was visible for a quarter of an hour. The meteor appears to have crossed the coast-line at a point near Terracina, to have passed over Piperno in a direction 7° W. of N., and, moving N.N.E. over Cori and Gennazzano, to have exploded over the latter town. After the lapse of two to three minutes, two reports were heard, the first like that of a cannon, the second like a series of from three to six guns fired in rapid succession. The greater part of the stone fell at Orvinio, over which place the second explosion appears to have taken place, and some fragments were carried further northward.

Six fragments of the meteorite, weighing collectively 3·396 kilog., have been found:—No. 1, weighing $4\frac{3}{4}$ grammes, fell with a hissing noise near a peasant at Gerano; No. 2, weighing 92 grammes, fell at La Scarpa, within ten metres of a farmer, who picked it up while hot; No. 3, weighing 622 grammes, was found two or three days after the fall a few centimetres below the surface, in a stubbled field at Pezza del Meleto, between Orvinio and Pozzaglia; No. 4, 1242·5 grammes in weight, was found a week after the fall, close to Orvinio:

[1] A. Secchi. *Compt. rend.*, lxxv. 655.—G. S. Ferrari. Richerche fisico-astronomiche intorno all' Uranolito caduto nell' agro Romano il 31 di Agosto, 1872. Roma: Tip. Bell. Arti. 1873.—P. Keller. *Pogg. Ann.*, cl. 171. *Mineralog. Mitt.*, 1874, 258.—M. le Chevalier Michel-Etienne de Rossi and G. Bellucci. *Atti dell' Acc. pontif. di nuovi Lincei*, 1873.—*Les Mondes*, 25th December, 1873.—L. Sipöcz. *Mineralog. Mitt.*, 1874, 244.—G. Tschermak. *Sitz. Ak. Wiss. Wien*, lxx. November Heft, 1874.

the grass around it had been somewhat singed; No. 5, weighing 432 grammes, was picked up a week after the fall at Pezza del Meleto; No. 6, weiging 1003 kilog., was found on the 8th May, 200 metres distant from No. 4, at a very trifling depth, while turning up the soil of a field.

At the time of the fall a man was passing the spot where fragments numbered 4 and 6 were found. Immediately after the explosion, he heard the sound of a heavy body striking the earth, and he fell on the ground with fear. At the same time, or a little later, a fire broke out in a barn filled with hay in the village of Affile, and the occurrence was, with general consent, ascribed to the meteorite.

In September, 1873, Keller learnt that two more small fragments had fallen near the village of Anticoli Corradi. The one fell near two boys who were tending cattle. They became alarmed at the hissing noise, and believing this projectile to be aimed by the Devil, they picked it up, and threw it far away from them. The other stone was observed to fall on the bare rock, and to break in pieces. The fragments were collected, but as they were held to be of no value, they were subsequently lost. In the case of this aerolite, as in that of others, the smaller appear to have fallen before the larger fragments.

The velocity of this fall must have been very slow. The authors do not state whether any of the fragments could be fitted together; their specific gravity ranged between 3·58 and 3·73—in one, richer in metallic constituents, it amounted to 4·598. Two of the fragments bear portions of the crust lying in pits and hollows. It is only $\frac{1}{2}$ mm. thick, has a pitch-black colour, and exhibits in some places a waxy lustre. The mass of the stone is of a lead grey colour, being darker than that of the aerolites of Pultusk and Monte Milone. A polished surface exhibits metallic grains, some 2 mm. in diameter, and a green silicate, probably olivine. The ground-mass appears to be made up of two minerals, one clear and uniform, the other dull and less homogeneous. The stone acts powerfully on the magnet.

In Ferrari's memoir is given a plan of the country near Rome, on which is indicated the track of the meteor and the positions where the stones fell. The line of flight, a singularly devious one, is seen to pass immediately over the summits of M. Leano, M. Sempreviso, M. Lapone, and quite near to that of M. Gennaro, the chief mountains of the district, and suggests the gravitating action of these more elevated masses of the earth's surface on the path of the meteor. A sketch of the latter, the trajectory of which is computed to have been inclined 27° to the plane of the horizon, accompanies the map.

The paper of M. Le Chevalier Michel-Etienne de Rossi gives the analysis and observations of Prof. Bellucci, of Perugia. When heated to 120° the powdered mineral lost 1·875 per cent., and by treatment with water a little potassium and sodium chloride were dissolved. (Compare with Daubrée's examination of the Lancé stone, page 220.) The magnet removed 29·04 per cent. and acid 45·04 per cent. The analysis of a portion of the stone gave the following numbers: silicic acid = 46·72; alumina = 16·84; magnesia = 1·97;

iron = 25·59; iron oxide (*fer oxydé*) = 4·82; sulphur = 2·24; nickel with trace of cobalt = 1·37; with traces of calcium, chromium, manganese, arsenic, and phosphorus. Two points are worthy of remark in this analysis: first, the astonishingly large amount of alumina present, far in excess of that found in any other meteorite. In the absence of a second and confirmatory analysis, it may be assumed that insufficient ammonium chloride was employed, and the greater portion of the 16·84 per cent. is magnesia, which was precipitated with the alumina. Secondly, the occurrence of arsenic, which is of extreme rarity, in a meteorite; it is stated to be present in the iron of Braunau and the olivine of the Atacama siderolite.

Tschermak's report of his examination of this stone appeared in the winter of 1874. The structure developed on cutting the stone is unusual and remarkable, consisting of light-coloured fragments (I.), surrounded by a compact dark cementing material (II.). The former are yellowish-grey, inclose spherules and particles of iron and magnetic pyrites; are, in fact, normal chondrite, and resemble the mass of the stone which fell at Seres in Macedonia (1818, June). The latter incloses numerous particles of iron and magnetic pyrites, for the most part uniformly distributed; the portion nearest the inclosed fragments bears very distinct indications of having been at one time fluid, and conveys the impression that this cementing material was at one time in a plastic condition while in motion. Along the boundary of these two very dissimilar portions flaws are seen, in which nickel-iron has crystallized in delicate plate-like forms; and here, moreover, the fragments are darker, harder, and more brittle than those of the centre, which argues the exposure of the cementing material to a very high temperature while in a plastic condition. Both portions have nearly the same density and apparently the same chemical composition and mineral characteristics. The Orvinio stone resembles, in fact, certain brecciated volcanic rocks which consist of a ground mass through which granular fragments of the same rock are distributed, as when older crystalline lavas are interpenetrated by others more compact and of a more recent period.

The light-coloured fragments are, as has been stated, chondritic; the spherules are usually of one kind, lying in a splintery matrix of the same mineral, containing some nickel-iron and magnetic pyrites. Among the transparent constituents, olivine is recognized by its imperfect cleavage; a second mineral, with a distinct cleavage along a prism of nearly quadratic section, is evidently bronzite; while a third, which occurs in fine foliated or fibrous particles, may be either identical with the above or be a felspathic ingredient.

The meteoric rocks possessing chondritic structure are regarded by Tschermak as tufas, which have undergone detrition; and their spherules to be such particles as, by their superior toughness, have, during the trituration of the rock, instead of breaking up into splinters, acquired a rounded form.

A black material is observed to coat the fragments of the rock and to fill the finer flaws existing between them, whereby their transparent character is considerably impaired; this has also been noticed in the meteorite of Tadjera (1867, June 9th).

The dark-coloured cementing material contains two ingredients: an opaque semi-vitreous constituent, and particles in every way similar to the dark crust of the fragments from which they may probably have been detached; many of them can still be recognized as olivine and bronzite. The nickel-iron and magnetic pyrites of this portion of the stone are more finely divided than in the fragments, and have often a rounded form. The metal of this portion, as well as in the other, exhibits no Widmannstättian figures; but in both, by treatment with acid, lines are developed like those of the Braunau iron.

The two species of rock: the chondritic fragments (I.) and the darker cementing material (II.): have the following composition:

	I.	II.
Silicic acid	38·01	36·82
Alumina	2·22	2·31
Chromium oxide	trace	trace
Iron protoxide	6·55	9·41
Magnesia	24·11	21·69
Lime	2·33	2·31
Soda	1·46	0·96
Potash	0·31	0·26
Iron	22·34	22·11
Nickel, with trace of cobalt	2·15	3·04
Sulphur	1·94	2·04
	101·42	100·95
Specific gravity	3·675	3·600

These results establish the similarity in composition of the two portions, and, as Tschermak points out, the erroneous character of Belucci's analysis, to which attention has already been directed.

Tschermak's paper is illustrated with a plate, giving a figure of the meteorite he examined; a drawing, actual size, of the section, showing very distinctly the appearances of fusion; and three microscopic sections, magnified 20 diameters, of the two rock varieties composing the greater part of the stone.

1872. November 3rd. 5·30 p.m.—Nairn, Scotland.[1]

A meteor of unusual brilliancy was observed to take a direction from E.S.E. about 20° from the horizon. The sky was so lighted up for two or three seconds that the observer could have picked a pin from the ground. Darkness followed, and again the light burst forth stronger than before, and shortly afterwards a sound was heard as if three or four cannon had been discharged at the distance of a quarter of a mile. The meteor appeared to move from the southern part of Banffshire, towards the centre of Inverness-shire, and to burst somewhere near the source of the river Nairn. It was also observed at Glasgow.—A second very bright meteor was seen about 9·15 (G. M. T.) at Bristol and Portsmouth,[2] passing from the zenith

[1] H. D. Penny. *Brit. Assoc. Report*, 1873, Obs. Luminous Meteors, 369.
[2] E. B. Gardiner. *Brit. Assoc. Report*, 1873, Obs. Luminous Meteors, 365.

down towards 10° E. of the Pleiades in Taurus. A sound as of an explosion was heard three seconds after its disappearance.

1872. November 13th. 2 a.m. "Sevenstones" Light-ship, Scilly Islands.[1]

A letter, addressed by the Secretary of the Corporation of the Trinity House to the President of the Royal Society, states that at the above hour a meteor burst over the "Sevenstones" light-vessel, moored about 9½ miles E. by N. of the Scilly Islands. The watch were struck senseless for a short period, and on recovery they observed "balls of fire falling in the water like splendid fireworks," while the deck was covered with cinders, "which crushed under the sailors' feet as they walked." The writer states that the "cinders" were, there is reason to fear, all washed off the decks by the rain and sea before daylight. Miss Carne, of Penzance, and Mr. Talling, of Lostwithiel, to whom I applied for information, did not succeed in obtaining any further details respecting this remarkable occurrence.

1872. November 30th. 2·8 p.m.—Slough, England.[2]

The descent of this 'meteor' was witnessed by Sir J. C. Cowell, who states that it fell one mile east of Slough, and about 150 yards south of the Great Western Railway. He writes that the phenomenon occurred during a short and sharp thunderstorm which passed over North Hants and East Berks. It is a question whether this was not a form of ball-lightning. "The explosion was similar to that of a heavy gun when fired." A sketch accompanying the notice represents the fire-ball striking a ploughed field, between the observer and some trees. It is not stated whether any search was made at the time for a meteorite.

(To be continued in our next Number.)

VI.—Postscript to a Paper on the Post-Pliocene Formations of the Isle of Man.[3]

By J. A. Birds, B.A.

When I sent the above paper to the Geological Magazine, I was not aware that a Sketch of the Geology of the Isle of Man, by Mr. John Horne, F.G.S., of the Geological Survey of Scotland, had been published in the Transactions of the Edinburgh Geological Society.[4]

A notice[5] of Mr. Horne's sketch afterwards appeared in the December Number of the Geological Magazine; and the author has since kindly sent me a copy of his paper.

I am happy to find that I am in agreement with Mr. Horne as to there being two Boulder-clays, with interglacial beds, represented in the Isle of Man; and, further, that there are abundant memorials left of the period of the great submergence.

Mr. Horne's account, too, of the striation of the rocks, and the

[1] R. Allen *Proc. Royal Soc.*, xxi. 122.
[2] Sir J. C. Cowell. *Nature*, 26th December, 1872.
[3] See the Geol. Mag., Dec. II. Vol. II. Feb. 1875, p. 80.
[4] Trans. Edinburgh Geol. Soc., 1874, vol. ii. part 3.
[5] Geol. Mag., Dec. II. Vol. I. Dec. 1874, p. 560.

origin of the Lower Boulder-clay (though I differ with him as to which is the Lower Boulder-clay), as produced by a resultant from the collision of the Scotch and Cumberland glaciers and from the advance of another great Irish glacier, seems to me very plausible, and may possibly be true. He, however, divides the Post-Pliocene, formations into, in *descending* order :—

1. Stratified gravels, sands, and shelly clays.
2. A Kame series.
3. Upper Boulder-clay = Scotch Maritime Boulder-clay.
4. Intermediate beds of stratified sands and gravel.
5. Lower Boulder-clay = Scotch Till.

And he accounts for the formation of the first two members of the series by supposing them to have accumulated, not without the aid of icebergs, during the great submergence; and the last three to have been formed during the first Glacial period, in which there was one or several intervals of retirement of the ice, when the intermediate beds were deposited.

In my paper I have taken the formations to occur in just the reverse order, viz. in ascending series :—

1. Lower Boulder-clay = Mr. Horne's shelly clays; passing up into

2. Middle Drift = Mr. Horne's stratified sands and gravels and Kame series; and thence into

3. Upper Boulder-clay, with intercalated beds of sand and gravel = his Upper and Lower Boulder-clays, with the same intercalated beds.

I may add that I regard my Upper Boulder-clay (yellowish-brown and bluish) as analogous to similar deposits in the mountains of the Lake District; and the Middle Drift and Lower Boulder-clay as analogous to similar deposits in the Blackpool cliffs.

The mode in which I conceive each member of the series to have been formed has been already indicated in my paper.

As to which is the true order of the formations, the question must be determined, of course, by reference to sections, such as that of which Mr. Horne has given a lithograph, near the mouth of the Ballure Glen, and by all sections thence along the northern base of the hills to Kirkmichael.

As far as my observation went, I identified the sands and gravels capping the clays at the northern end of the island with similar sands and gravels in the cliffs at Kirkmichael, and on the shore at the Bay of Peel.

A priori, however, is it not against Mr. Horne's view of his Lower Boulder-clay being really such that there should be intermediate formations of sand and gravel when the cold was at its extreme, and the ice, according to his showing, 2,000—3,000 feet thick? Is it not much more probable that these interglacial beds should have been formed during the Upper Boulder-clay period, when the cold was much less and the ice thinner?

And secondly, if all the deposits are assigned to the first glacial period and the great submergence, what memorials are left, beyond some possible moraines, of the second glacial period, or the times next preceding and following it? Surely there ought to be such if the land has not been submerged since.

I would take this opportunity of correcting an error of the press in my previous paper. In the diagrams, p. 83, for "Account of the Isle of Man," read "Antiquity of Man;" also, for Turby read Jurby, pp. 84 and 85.

In reply to Mr. Kinahan's letter in the April Number of the Geological Magazine, I may be allowed to say that he seems to assume that I had seen the deposits to which he refers, and had been writing from personal observation. In this he is mistaken, as I have never been in Ireland. In alluding to the order of the Irish glacial series, I relied solely on the authority of Professor Hull's paper.[1]

Mr. Kinahan dissents: and says that an Upper Glacial Drift (Boulder-clay) has not been proved to exist in Ireland; but it is clear that he says so on the ground of a different definition of Glacial Drift, implied if not expressed, according to which it is never found stratified or rearranged:[2] whereas according to the views expressed in the paper above referred to, being "generally marine,"[3] it would naturally often occur under both conditions.

NOTICES OF MEMOIRS.

I.—On the Origin of the Chesil Bank, and on the Relation of the Existing Beaches to past Geological Changes, independent of the present Coast Action.[4]

By Professor Joseph Prestwich, M.A., F.R.S., V.P.G.S., Assoc. Inst. C.E.

THIS remarkable bank of pebbles, extending from Portland to Abbotsbury, a distance of nearly 11 miles, was described with great accuracy by Sir John Coode, M. Inst. C.E., in 1853 (*vide* "Minutes of Proceedings Inst. C.E.," vol. xii. page 520).[5] It was then 43 feet high and 600 feet wide at the south end, decreasing to 23 feet high and 510 feet wide at the north end. The pebbles diminished in size from Portland to Abbotsbury. Sir John Coode also stated that the shingle consisted chiefly of pebbles of chalk-flint, with a small proportion of others of red sandstone, porphyry and jasper, none of which could have been derived from local rocks. In order to determine their origin, he examined the coast from Portland to Start Point, and traced the flints to the chalk cliffs between Axmouth and Lyme, and the red sandstone, porphyry, and jasper pebbles to the New Red Sandstone of Budleigh Salterton, and other places in Devonshire; whence he concluded that the only source

[1] Geol. Mag. July, 1871, pp. 294 sq.
[2] Geol. Mag. April, 1874, p. 171, and April, 1875, p. 189.
[3] Geol. Mag. July, 1871, p. 299.
[4] Being the substance of a paper read at the Tenth Ordinary Meeting of the Institution of Civil Engineers held on Tuesday evening, the 2nd of February, 1875.
[5] See also a valuable paper on the Chesil Bank by Messrs. H. W. Bristow, F.R.S., and W. Whitaker, B.A., F.G.S., in Geol. Mag., 1869, Vol. VI. Pl. XIV. and XV. page 433.

from which the shingle of the Chesil Bank could have been derived was between Lyme Regis and Budleigh, and that it was propelled eastward along the coast to the Chesil Bank by the action of wind-waves, due to the prevalent and heaviest seas. The objection to this view urged at the time by the Astronomer Royal was, that the largest shingle occurred at the Portland end of the beach, or the most distant part from which it had travelled.

More recently an old "raised beach," standing from 21 feet to 47 feet above the present beach, had been discovered on the Bill of Portland, and Professor Prestwich showed that this beach contained all the materials found in the Chesil Bank, including also numerous chert pebbles from the Upper Greensand of the cliff between Bridport and Sidmouth. This raised beach was not due to any existing agency, but to causes in operation at a geological period so remote as the end of the Glacial period, and before the land had assumed its present position and shape. Remnants of this beach could be traced in or on the present cliffs, at intervals from Brighton to the coast of Cornwall, being more numerous in Devon and Cornwall, as the rocks were harder, than among the softer strata of Dorset and Hants, where, with few exceptions, the old line of cliff had been worn back and deeper bays formed. The travel of the shingle of this old beach was generally like that of the present beach from west to east.

The Author considered that the action of the "Race" off Portland, and of the tidal waves during storms, combined to drive the shingle of the old beach at the Bill, and of that portion of it which must be spread on the sea-bed westward of Portland, on to the south end of the Chesil Bank, whence the shingle was driven northward to Abbotsbury and Burton, by the action of the wind-waves, having their maximum force from the S.S.W., a direction which he showed to be the mean of the prevalent winds. Here, these wind-waves became parallel with the coast, and the westward movement ceased about Bridport, beyond which point the shingle travelled in the opposite direction, viz. from west to east, or from the coast of Devon to that of Dorset; the quartzite pebbles from the conglomerate beds of Budleigh Salterton, which travelled from that part of the coast eastward to and beyond Sidmouth, gradually diminishing in numbers as they approached Lyme, very few, if any, reaching Bridport. This conclusion was in accordance with the facts:—1. That the pebbles of the Devonshire and Dorset strata, which formed the shingle of the "raised beach," constituted also the bulk of the Chesil Bank. 2. That there were also, in that bank, pebbles of the rocks and flint of Portland itself. 3. That the largest pebbles occurred at the Portland end of the bank, the pebbles decreasing gradually in size to Abbotsbury. The large dimensions of the bank he attributed to the great accumulative and small lateral action of the waves.

Professor Prestwich next discussed the questions connected with the shingle of the south coast generally, and showed that the greater part of it was derived indirectly from beds of quaternary gravel and débris, from the wreck of the "raised beach," and partly from the strata of the chalk and other cliffs, and not altogether or directly from the present cliffs. He noticed, also, the westward movement of the shingle from Lulworth towards Weymouth, owing to the interference of the Isle of Portland with the force of the S.S.W. wind-waves, and considered that none of the Devon and West Dorset shingle beach now passed the Bill of Portland, and that other such breaks might exist to the eastward whenever similar conditions were repeated. He explained the origin of the Fleet, like that of the Weymouth backwater, and of the Lodmore marshes, by the growth of the Chesil Bank on the one hand, and of the Ringstead and Weymouth Beach on the other, gradually damming in portions of the old coast-line. Those beaches themselves travelled on a line along which the opposing forces of the wind-waves and tidal currents and the inertia of the mass to be moved were balanced. These views were stated to be in conformity with the theoretical opinion expressed on abstract grounds by the Astronomer Royal, and with the experience of practical persons residing on the spot.

II.—Review of Professor Schimper's Fossil Mimoseæ.[1]

In the prefatory matter to the present paper I have made no reference to any fossil remains of *Mimoseæ;* for at the time of drawing it up I had no ready means of ascertaining what evidence on the subject had been supplied by palæontologists, and I had not yet heard from Professor Schimper, who had kindly promised to communicate with me on the subject. Since, however, the early sheets of this paper were printed off, the third volume of his magnificent work on Vegetable Palæontology has reached us; and in it I find that a number of supposed fossil *Mimoseæ* from the Central-European Tertiary are described and figured, and referred severally to the genera *Prosopis, Inga, Entada, Mimosa,* and *Acacia.* The great majority of the species so determined are founded on impressions of leaves only; and these I pass entirely over; for although without collateral evidence it is impossible to deny that they may belong to the genera in question, it is equally impossible to affirm that they do so belong; for none of them show forms or venation exclusively characteristic of any of these genera. I thus see no reason to conclude on this evidence that any *Inga, Mimosa,* or Phyllodineous *Acacia* was in part of the Tertiary period an inhabitant of that part of Europe, when other evidence would tend to an opposite conclusion. With regard to *Prosopis,* the presumption that it might have been there is to my mind neither confirmed nor refuted by the fossil impressions described as *Prosopis* leaflets. On the other hand, those fruits of which so many excellent impressions are figured by Schimper, point to species of *Acacia, Entada,* and perhaps *Albizzia,* very similar to those now found in Africa—a case analogous to that of the *Podogonium,* of which specimens so very perfect have been preserved as to enable us satisfactorily to identify it as closely allied to some African Cæsalpineous genera not yet quite extinct.

Descending to particulars, the fruits figured by Schimper, pl. cvi.

[1] Extracted from a revision of the sub-order *Mimoseæ*, by George Bentham, Esq., F.R.S., 1875. Linn. Trans. vol. xxx. pt. 3, pp. 646, 647.

figs. 4, 5, 6, 7, 12, and 13, all referred to *Acacia*, are probably correctly determined, and represent species of the groups *Gummiferæ* and *Vulgares*, both of which are at the present day abundant in Africa. Fig. 4, indeed, if the leaves of figs. 1 and 2 really belong to it, must be very near to the *A. catechu* of the present day. The pods figs. 20 and 21, are determined as *Mimoseæ*; but if I had had such pods shown to me in a fresh state, I should have referred them without hesitation to *Acacia*. Fig. 20 is exceedingly like the pod of *A. constricta* from the United States, and very near to that of a few very narrow-fruited gummiferous *Acaciæ* of Africa, as well as to some of the Australian *Phillodineæ*. Fig. 21 is very like the pod of several *Acaciæ* of the group *Vulgares*, which, when rotting, often break up irregularly, as shown in the drawing. Both are very unlike any *Mimosa*-pods known to me. In this genus the lines separating the articula of the valve are always quite straight, and at right angles to the margin. Figs. 8 and 9, referred to *Acacia*, are more like the pods of some species of *Cassia*. Figs. 23 and 24 may represent *Albizzia*-pods. Fig. 22 may be an *Entada*, as determined, though not any recent species; but it is also nearly as much like some *Ormosia*-pods. Both these genera are still represented in Africa.

REVIEWS.

I.—Geological Map of London and the Neighbourhood.

THE publication by the Geological Survey of a Map with London as a centre, will be hailed with satisfaction by those interested in the geology of the metropolis, and of the country within easy distance around it. Formerly one had to procure four distinct sheets of the Geological Survey Map of England, in order to obtain the whole of London geologically coloured, and then one obtained actually more than was necessary for the illustration of London geology or convenient as a diagram for the wall of the library. The present Map embraces an area bordered on the North by Blackmore, Epping, Waltham Abbey, Potter's Bar, Watford, and Chesham Bois; and on the West by Amersham, Windsor, Chertsey, and Cobham; on the South by Epsom, Croydon, Farnborough, and Shoreham; and on the East by Gravesend, Grays Thurrock, Brentwood, and Frierning.

The Map is published both with and without drifts; but it need hardly be said that for most practical and scientific purposes the map showing drifts is alone desirable, for no geological map on a scale of one-inch to a mile can be considered complete if the superficial deposits be omitted. Their influence on the scenery of the district is trifling, for the main features were sketched out before the drift deposits were laid down: they rest indifferently upon the Tertiary strata and Chalk, and yet many of them, and particularly the Glacial Deposits, have suffered much denudation.

The formations represented include the Chalk, Thanet Beds, Woolwich and Reading Beds, Oldhaven Beds, London Clay, and Bagshot Beds. The Drift deposits, which are entitled equally to rank as formations, include the Glacial Deposits of Boulder-clay, Sand and Gravel; the Brick-earth and Clay-with-flints on the Chalk tracts; and the Alluvium, Brick-earth and Gravel of the valley of the Thames and its tributaries.

Under the term Pebble-gravel are included deposits of pebbly gravel whose age is uncertain; many such deposits are undoubtedly older than the Boulder-clay, but some of them may possibly be Post-Glacial.

The country was geologically surveyed by Messrs. H. W. Bristow, W. Whitaker, T. R. Polwhele, R. Trench, W. B. Dawkins, H. B. Woodward, F. J. Bennett, W. A. E. Ussher, J. H. Blake, and C. E. Hawkins.

II.—Prof. O. C. Marsh on the Ancient Lake-basins of the Rocky Mountain Region.[1]

NO fact which has come under our notice bearing upon the antiquity of the great North American Continent as an "Old Land Area," has appeared to us more wonderful than the discovery in the Rocky Mountain Region of undoubted evidences of the former existence of a succession of vast fresh-water lakes. The deposits with which each is filled prove them to have been respectively of Eocene, Miocene, and Pliocene age; the fauna being entirely distinct in each and also quite different from that now existing.

The one first discovered and best known, called Green River Basin, lies between the Rocky Mountains and the Wasatch range, in the depression now drained by the Green River. It has the Uintah Mountains for its southern border, and extends north as far as the Wind River range. This basin was visited by Professor Marsh in 1868, but not fully explored until 1870, when he traced the deposits and determined its Eocene age. From it he has obtained 150 species of extinct vertebrates, corresponding with those of the Paris Basin, some even indicating a still lower horizon. These fresh-water deposits are of enormous thickness, 6000 feet at least; nearly or quite horizontal, and resting unconformably on the subjacent Cretaceous coal-bearing rocks.

A second and larger lake existed in Eocene times south of the Uintah Mountains at 2000 feet lower level than the northern lake, and receiving part of its waters from that source. Its deposits were also explored by Prof. Marsh in 1870.

The fauna entombed in these Eocene lakes is essentially the same, and indicates a tropical climate. This is especially seen in the great number of the remains of Tapiroid mammals, monkeys, crocodiles, lizards, and serpents, discovered by Professor Marsh in these deposits.

Those of the *Dinocerata*, the largest of Eocene mammals, have only been found as yet in the northern basin.

The Miocene (White River) Lake-basin appears to have extended south from the Black Hills to the Republican River, or from the 44th to the 40th parallel of latitude.

[1] See the American Journal of Science and Art, vol. ix. no. 49, p. 49.

Its western border was the Rocky Mountains, and its eastern margin not far from the 99th meridian. The strata in this basin are all nearly horizontal, and indicate deposits formed in quiet waters. They attain 300 feet in thickness, and rest unconformably on strata referred by Prof. Marsh to the Cretaceous coal-bearing series of the Rocky Mountains.

The fauna of the White River Lake-basin indicates a much less tropical climate than that of the Eocene lakes. The *Brontotheridæ*, the largest known Miocene mammals, are peculiar to this deposit.

Another Miocene lake occurs on the Pacific slope near the centre of the State of Oregon.

A far larger Pliocene Lake-basin was formed directly over the eastern Miocene Basin, but extending much further east and south; covering an area at least five times as great as the older lake. The Pliocene deposits, which attain 1500 feet in thickness, and lie nearly horizontal, indicate by their fauna a warm temperate climate. The more common mammals are the Mastodon, Rhinoceroses, Camels and Horses, the latter were especially abundant.

It is earnestly to be hoped that the vast collections of fossil remains secured with so much labour by Prof. Marsh from these and the subjacent Cretaceous deposits may ere long be published for the satisfaction both of European and American naturalists.

REPORTS AND PROCEEDINGS.

Geological Society of London.—I.—February 24th, 1875.—John Evans, Esq., V.P.R.S., President, in the Chair.

Before proceeding to the business of the Meeting, the President spoke as follows:—

I cannot proceed to the ordinary business of this evening without making some allusion to the melancholy event by which so deep a gloom has been cast over all of us since the Anniversary Meeting on Friday last. I little thought that in speaking of the services rendered to this Society fifty years ago by Sir Charles Lyell, services which in various ways he has ever since continued to render, that we should so soon have to lament his irreparable loss. By every one of us he was regarded as the leader of our science, by most of us as our trusted master, and by many of us as our faithful friend. He has lived to see the truth of those principles for which he so long and earnestly contended accepted by nearly all whose opinions he valued; and in future times, wherever the name of Lyell is known, it will be as that of the greatest, most philosophical, and most enlightened of British, if not indeed of European geologists.

The following communications were read:—

1. "On the Murchisonite Beds of the Estuary of the Exe, and an attempt to classify the beds of the Trias thereby." By G. Wareing Ormerod, Esq., M.A., F.G.S.

This paper may be regarded as a continuation of one read by Mr. Ormerod before this Society in 1868. After noticing the mineralogical character of the Murchisonite, Mr. Ormerod described, first, the Red Sandstone beds by the sea-shore. To the east of Exmouth he considered that they were "Keuper," which extended inland to a fault running to the south of Lympstone. A conglomerate rock at the Beacon at Exmouth was probably the upper bed of the "Bunter," and this the author considered to be the same rock that occurred at Cockwood on the right bank of the Exe. This overlies soft red rock, containing occasionally fragments of various rocks, and in the upper part a slight trace of Murchisonite. At Dawlish a soft conglomerate containing Murchisonite in great abundance occurred, this extended inland about two miles. On the westerly side of Dawlish conglomerate beds cropped out, containing fragments of granitic and porphyritic rocks, quartz, Lydian-stone; and here the limestone fragments containing animal remains first occurred. After passing the Parson-and-Clerk Tunnel, these conglomerate beds ceased until reaching Teignmouth, and the cliffs consist of soft beds. At Teignmouth the conglomerates, with limestone, again commenced, and continued to near St. Mary's Church, in this part alternating with soft sandy or clayey beds. To the north of the fault at Lympstone the Keuper did not appear by the Exe, and the conglomerate with limestone had not been noticed, being possibly buried under the Greensand of Haldon. The beds north of this point on both sides of the Exe were the soft Red Sandstone, with a trace of Murchisonite, and the underlying Murchisonite Conglomerates, and near Haldon House beds that it was considered were possibly those to the west of Dawlish occurred. These beds were broken up by various faults running in both north and south and east and west directions. In the district under consideration it was shown that the soft sandy beds, with a trace of Murchisonite, and the underlying bed of Murchisonite Conglomerate occurred in various places, and in such a manner that there could not be any doubt of their identity; these the author considered as marking a clear division in the Red Sandstone.

2. "On some newly exposed sections of the 'Woolwich and Reading beds' near Reading, Berks." By Prof. T. Rupert Jones, F.R.S., F.G.S., and C. Cooper King, Esq., R.M. Art., F.G.S.

The authors described the section of the Lowest Tertiary Beds lately exposed at Coley Hill, Reading, Berks, comparing it with other sections in the neighbourhood described by Buckland, Rofe, Prestwich, and Whitaker. At one point in the section oyster-shells are wanting in the Bottom Bed, as observed also by Whitaker at Castle Kiln. At the same part of the section the leaf-bearing blue clays are also absent, but are continued by irregular thin seams of derived clay and clay-galls, with broken lignite, occasional grey flints, and by at least one green-coated flint and pebble of lydianite. At another point, where the blue clay still exists, very numerous and large lumps of clay, rolled and often inclosing subangular flints, lie in the sand over the leaf-bed. Some of these clay-galls have passed into concentric nodules of ochre and limonite. The probable derivation of the two sets of clay-galls is from pre-existing clay-beds—probably the blue shale, one from its worn end and the other (upper one) from a terrace or ledge in its thickness—by the action of varying currents in an estuary at different levels. The clay-galls of the upper series vary much in character; some are of dense dark brown and light coloured clays, others of sandy blue and grey clays, many have involved sand and flints from an old shoal or beach. A probably analogous band of flints has been noticed at Red Hill, Berks, by Prestwich. The direction of the currents wearing away the clay bands and depositing the galls and sands was suggested; and these observations were offered as further materials in working out the hydrography and history of the Lower Tertiaries.

3. "On the Origin of Slickensides, with remarks on specimens from the Cambrian, Silurian, Carboniferous, and Triassic formations." By D. Mackintosh, Esq., F.G.S.

This paper was founded on specimens, a selection of which was exhibited. The author stated that his observations led him to believe that true slickensides are produced by the movement of one face of rock against another, *accompanied by partial fusion.* He indicated that in many cases the slickensided surfaces are not only polished and striated, but also hardened, and that there is an imperceptible gradation from this hardened film to the ordinary structure of the rock.

II.—March 10, 1875.—John Evans, Esq., V.P.R.S., President, in the Chair.—The following communication was read:—

"The Rocks of the Mining Districts of Cornwall, and their relation to Metalliferous Deposits." By John Arthur Phillips, Esq., M.I.C.E., F.G.S.

In this paper the author adduced numerous facts observed by him in the examination of the rocks of the mining districts of Cornwall, which led him to the following conclusions:—The clay-slates of Cornwall differ materially in composition, but no re-arrangement of their constituents could result in the production of granite. Some of the "greenstones" of the Geological Survey Map are volcanic rocks contemporaneous with the slates among which they are found, whilst others are hornblendic slates, diorites, etc. Granites and elvans having a similar chemical and mineralogical composition, were probably derived from the same source; but the volume of the bubbles in the fluid-cavities of both having no constant relation to the amount of liquid present, do not afford any reliable data from which to calculate the temperatures at which these rocks were respectively formed. The stone-cavities of elvans, and probably of some other rocks, are often the results of the irregular contraction, before the solidification of the base, of imbedded crystals of quartz. In rocks having a glassy base, glass-cavities will be produced. The vein-fissures of the tin- and copper-bearing lodes of Cornwall were produced by forces acting after the solidification of the elvans, but in the same general direction as those which caused the eruption of the latter; and these fissures were afterwards filled with minerals deposited by chemical action from water and aqueous vapours circulating through them, but not necessarily at a high temperature. How far these deposits were produced by water rising from below or influenced by lateral percolation cannot be determined; but the effects produced on the contents of veins by the nature of the inclosing rock, and the occurrence of deposits of ore parallel with the line of dip of the adjoining country, lead to the conclusion that lateral infiltrations must have materially influenced the results. Contact-deposits and "stockwerks" have been formed by analogous chemical action, set up in fissures resulting from the junction of dissimilar rocks, or in fractures produced during the upheaval of partially consolidated eruptive masses. The alteration produced in stratified deposits in the vicinity of eruptive rocks is probably often due to similar percolations. It is not improbable that quartz may sometimes retain a certain amount of plasticity after it has assumed a crystalline form.

III.—March 24, 1875.—John Evans, Esq., V.P.R.S., President, in the Chair.

The President announced that the late Sir Charles Lyell had bequeathed to the Society the sum of £2000 for the purposes stated in the following extract from his Will:—

"I give to the Geological Society of London the Die executed by Mr. Leonard Wyon of a Medal to be cast in Bronze and to be given annually and called the Lyell Medal, and to be regarded as a mark of honorary distinction and as an expression on the part of the Governing Body of the Society that the Medallist (who may be of any Country or either sex) has deserved well of the Science. I further give to the said Society the sum of Two thousand pounds (free of legacy duty) to be paid to the President and Treasurer for the time being, whose receipt shall be a good discharge to my Executors; and I direct the said sum to be invested in the name of the said Society, or of the Trustees thereof, in such securities as the Council shall from time to time think proper, and that the annual interest arising therefrom shall be appropriated and applied in the following manner: not less than one-third of the annual interest to accompany the Medal, the remaining interest to be given in one or more portions at the discretion of the Council, for the encouragement of Geology or of any of the allied Sciences by which they shall consider Geology to have been most materially advanced, either for travelling expenses or for a memoir or paper published or in progress, and without reference to the sex or nationality of the author or the language in which any such memoir or paper may be written. And I declare that the Council of the said Society shall be the sole judges of the merits of the memoirs or papers for which they may vote the Medal and Fund from time to time. And I direct that the legacy hereinbefore given to the said Society shall be paid out of such part of my personal estate as may be legally applicable to the payment of such bequests."

Prof. Prestwich said that when he first joined the Geological Society, Sir Charles Lyell, or Mr. Lyell, as he was then, was one of its junior leaders. When his first book appeared, the views advocated in it were regarded with considerable disfavour; but he supported them by other writings subsequently published, and lived to see them generally received. His words justly carried weight over the whole scientific world, and had greatly increased the number of students of geology, and consequently of Fellows of the Geological Society. For his own part Prof. Prestwich added that, although he might differ from Sir Charles Lyell in some of the conclusions at which he had arrived, all must agree that the manner of proceeding from the known to the unknown adopted by him was the only true method. In conclusion Prof. Prestwich proposed the following resolution:—"That this Meeting, having heard the announcement of the bequest made to the Geological Society by the late Sir Charles Lyell, desire to record their deep sense of the loss the Society has sustained by his death, and their grateful appreciation of the liberal bequest for the advancement of geological knowledge placed at their disposal by their late distinguished Fellow."

Mr. Warington W. Smyth expressed the pleasure he felt in seconding the motion made by Prof. Prestwich, and said that it was with a mingled feeling of sadness and satisfaction that he had heard the announcement just made from the Chair. As a boy he had heard a lecture on geology given by Sir Charles in a room in Hart Street, Bloomsbury, and it was pleasant to recollect how interesting he made the subject. His audience might have consisted of twenty persons. Mr. Smyth well remembered "young Lyell," as he used to be called by Admiral Smyth, coming to visit him at his school at Bedford, and challenging the boys to play at football, when he proved himself to be one of the most active among them. He had a vivid recollection of a holiday passed in boating on the Ouse, when Sir Charles Lyell had provided himself with a plummet and string, and set himself to measure the river. He tested its depth, velocity, sediments, etc., and showed the party how, from such data, the volume of water that flowed down the river, and the quantity of sediment that it carried to the sea, might be calculated. Sir Charles was a great collector of facts with a purpose in view. Mr. Smyth concluded by expressing his satisfaction at finding that this Society was uppermost in the mind of his old friend at the close as during the whole course of his well-spent life.

The following communications were read:—

1. "On the Occurrence of Phosphates in the Cambrian Rocks." By Henry Hicks, Esq., F.G.S.

In this paper the author showed from experiments that the Cambrian strata in Wales contain a far greater amount of phosphate and carbonate of lime than had hitherto been supposed. The results published by Dr. Daubeny some years ago, and which have since received the support of some eminent geologists, were proved therefore to be entirely fallacious when taken to represent the whole Cambrian series; for though some portions show only a trace of these ingredients, there are other beds both interstratified with and underlying these series, which contain them in unusually large proportions. The author, therefore, objects to look upon Dr. Daubeny's experiments as tending in any way to prove that the seas in which these deposits had accumulated contained but little animal life, and that we had here approached the borders of the lower limit of organic existence. He contended that the presence of so much phosphate of lime, and also of carbonate of lime, as was now proved by analyses made by Mr. Hudleston, F.C.S., Mr. Hughes, F.C.S., and himself, to be present in series of considerable thickness in the Longmynd group, Menevian group, and Tremadoc group, proved that animal life did exist in abundance in these early seas, and that even here it must be considered that we were far from the beginning of organic existence. The amount of phosphate of lime in some of the beds was in the proportion of nearly 10 per cent., and of carbonate of lime over 40 per cent. The proportion of phosphate of lime, therefore, is greater than is found in most of what have been considered the richest of recent formations. The amount of P_2O_5 was also found to increase in proportion to the richness of the deposit in organic remains. It was found that all animal and vegetable life had contained it from the very earliest time; but it was apparent that the Crustacea were the chief producers of it in the early seas; and of the Crustacea, the Trilobites more particularly. It was always found where they were present, and the shell of some of the larger trilobites, as now preserved, contained as much as from 40 to 50 per cent. of phosphate of lime. The analyses made by Mr. Hudleston and the author of recent Crustacea proved that they also contain P_2O_5 in very considerable proportions.

In the second part of the paper the author showed that where intrusive dykes had passed through or between the beds containing the phosphate of lime, the beds for some distance on each side of the dykes had undergone a considerable change. Scarcely a trace of the P_2O_5 or of the lime was now to be found in them, though it was evident that before the intrusions into them had taken place, they, like the other portions of the beds, had evidently contained both ingredients in considerable proportions. It was well known that heat alone could not separate P_2O_5 from lime; therefore he found it difficult to account for this change in the character of the beds, unless it could be produced by gases or watery vapour passing into them at the time the intrusions took place. He thought it even probable that the dykes, which in some parts are found to contain a considerable amount of lime and also of P_2O_5, might have derived these, or at least some portions of these, from the beds through which they had been forced, and which must have been broken up and melted as they passed through them. There are no contemporaneous tuffs known in Wales of earlier date than the Llandeilo beds; and he thought these dykes belonged to that period, and that they were injected into the Lower Cambrian beds after from 8,000 to 10,000 feet of deposit had been superimposed. In an agricultural point of view the author considered that the presence of so much phosphate of lime in some of the series of beds must be a matter of great importance; and on examining the districts where these series occurred, he invariably found the land exceedingly rich.

Mr. Hudleston gave the results of the analyses made by him at the request of Mr. Hicks. He found in a portion of dark grey flaggy rock taken from close to a fossil 1·62, in a portion of black slaty rock containing trilobites, but in contact with trap, 0·11, in a portion of the shell of a trilobite 17·05, and in the trap above mentioned 0·323 per cent. of phosphoric anhydride. A lobster-shell dried at 100° C. gave 3·26, an entire boiled lobster (undried) 0·76, and a boiled lobster without shell 0·332 per cent. of P_2O_5. If the analysis of an entire lobster be correct, he estimated that a ton of boiled lobsters would contain about 17 lbs. of phosphoric anhydride. In the analysis of the shell of a trilobite there appears to be a great excess of phosphoric acid, which Mr. Hudleston thought must be due to substitution.

2. "Note on the Structure of the Phosphatic Nodules from the top of the Bala Limestone in North Wales." By M. Hawkins Johnson, Esq., F.G.S.

In this paper the author described the appearances presented by thin sections made from some of the phosphatic nodules and shales described by Mr. D. C. Davies, F.G.S., in his recent paper. In both nodule and shale he finds structure which he is inclined to identify with sponge-structure; but the mass also contains innumerable foreign bodies, chiefly fragments of the shells of Mollusca and Crustacea, with many irregularly ovate bodies that remind him of *Coscinopora*, and some that may be sponge-spicules. The author enumerated fourteen nodular formations from various localities and of various composition, in which he has detected organic structure, and to which he therefore assigns an organic origin; and he protested against the application of the term "concretionary" to such bodies.

3. "On the Maxillary Bone of a new Dinosaur *Priodontognathus Phillipsii*, contained in the Woodwardian Museum of the University of Cambridge." By Harry Govier Seeley, Esq., F.L.S., F.G.S., Professor of Physical Geography in Bedford College, London.

The bone described in this paper was indicated by the author in his "Index to the Aves, Ornithosauria, and Reptilia in the Woodwardian Museum," under the name of *Iguanodon Phillipsii*. Further examination and the detection of successional teeth resembling those of *Scelidosaurus*, and those referred by Prof. Huxley to *Acanthopholis*, induced him to regard the species as representing a new genus, most nearly related to *Hylæosaurus*. The specimen consists principally of the external and alveolar portion of the left maxillary bone, which is $4\frac{7}{8}$ inches long, the alveolar part being $4\frac{1}{2}$ inches, and the remainder made up by a posterior spur for connexion with the malar. From the middle of the upper margin springs an ascending nasal process separating the orbit from the nasal aperture. The presence of the posterior spur, or jugal process, seems to indicate an affinity to the Iguanodontidæ, notwithstanding the resemblance of the teeth to those of *Scelidosaurus*. The teeth, which are seen in their sockets, have their crowns resembling those referred to *Echinodon*, *Scelidosaurus*, and *Acanthopholis*, especially the last, differing chiefly by being relatively narrower, by having only 5–7 denticles on each side, by wanting the thickening at the base, and by terminating in a sharp point. The author described in detail the characters presented by the fossil, and indicated their bearing upon its systematic position. It was imbedded in a small slab of yellow sandstone, which also contained a specimen of *Pecten vagans*, and is probably of Great Oolite age.

4. "Description of a new species of the genus *Hemipatagus*, Desor, from the Tertiary Rocks of Victoria, Australia; with notes on some previously described species from South Australia." By R. Etheridge, jun., Esq., F.G.S.

In this paper the author described a new species of the genus *Hemipatagus*, under the name of *H. Woodsii*, and appended to this description some remarks on the characters of *Psammechinus Woodsii*, Laube, and *Micraster brevistella*, Laube, and *Monostychia australis*, Laube; and also a Synoptical List of the Australian Tertiary Echinodermata hitherto described.

CORRESPONDENCE.

SUBMERGED FORESTS.

Sir,—In your Number for May, 1868, Vol. V. p. 244, I had the honour to state that what are called "submerged forests" occur without any sinking of the land or rising of the sea, and that "they are all *choked-up estuaries*." More at large, this was first argued in the chapter on the "Travelling of Sea-beach" in "Rain and Rivers." I endeavoured to show that, before the engineer with his iron pipes and sluices *let* the streams out at low-water, and *kept* the sea out at high-water. Nature, in millions of cases, had partially done the same by running pebble banks across the mouths of small estuaries; that she had thus drained land below high-water mark, and had grown trees thereon. Mr. Kinahan (Valleys, and their Relation to Fissures, Fractures, and Faults, p. 208) replies that oak and most other trees cannot be grown except on drained land, which could never exist naturally below high-water mark." Lest people should take this unsupported *ipse dixit* negative for granted, may I state an imaginary case in exemplification of my theory? We all see the volume of water which passes under our bridges in London during the flood-tide, and most of us would at once allow that, directly as this flow was checked, the volume of water and the height of high-water would decrease. Suppose that at low-water Puck were to replace London-bridge with a bank of pebbles higher than high-water, The flood-tide, instead of flowing, would filter through the pebble-bank. Suppose this filtration and the river water to rise only to half-tide mark, and that the water then filters out with the receding tide. The slopes between the former half-tide and high-water mark would become "drained land," and would grow any trees to any size. Now suppose Puck to shift his pebble-bank to the site of Southwark-bridge. The trees between that and London-bridge would die from being flooded every twelve hours, and their roots would be seen below high-water mark. In nature this results from the sea eroding the line of coast, driving the pebble-bank landward, and exposing the roots which it had covered.

So-called submerged forests may be seen on the south coast opposite the middle of Hastings; at the mouth of Mantell's "Diluvial valley" at Pebblesham; at the west end of St. Leonard's; at Pevensey Level, near Eastbourne; and at Torre Abbey, near Torquay. Roman remains on Dover beach prove no submergence for nearly 2,000 years, while raised beaches prove ancient upheaval.

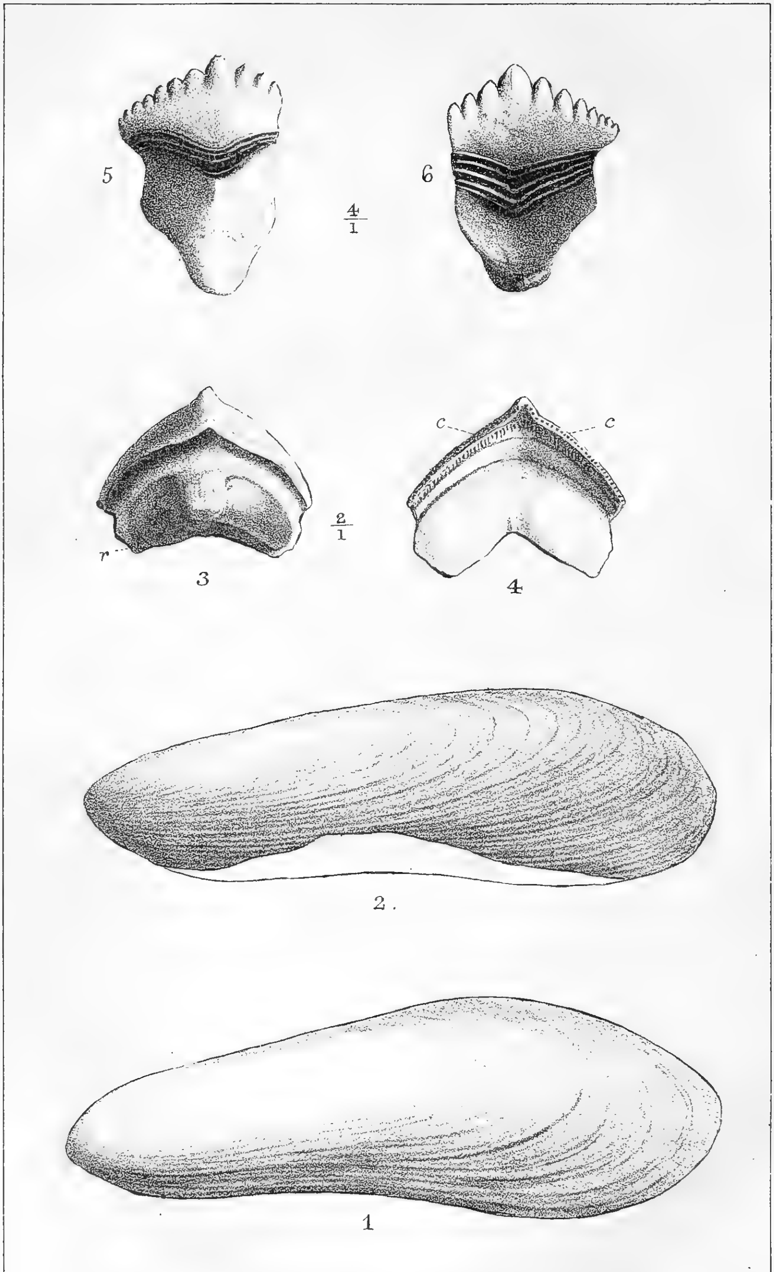
Brookwood Park, Alresford. George Greenwood, Colonel.

ON A NEW LAND-SHELL FROM THE GAULT OF FOLKESTONE.

Sir,—I have the pleasure to announce the discovery of (if I am not in error) the first land-shell of the Upper English Secondary Deposits. The specimen in question is a *Helix*, closely resembling the common garden snail, *H. nemoralis*. It is somewhat depressed without being flat, and is not quite symmetrical in outline, as it is longer one way than the other. Test thin, nearly smooth; sutures well defined, giving the whorls a flat concave appearance; lip, slightly reflected. As the upper portion of the specimen only is exposed, I am unable to say if the shell is umbilicated or not. Formation, Gault; locality, Folkestone.

Should it prove a new species, as I believe it to be, I propose naming it *Helix Woodwardi*.

Alfred Bell.



G. R. De Wilde, del et lith. W. West & Co. imp.

New Carboniferous Fossils.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. II.

No. VI.—JUNE, 1875.

ORIGINAL ARTICLES.

I.—On some Undescribed Carboniferous Fossils.

By R. Etheridge, Jun., F.G.S.;
Of the Geological Survey of Scotland.

(PLATE VIII.)

THE following species of *Modiola* is common to the Carboniferous Limestone series of England and Scotland, and appears to have been hitherto undescribed from them, although it may, perhaps, be identical with an American Sub-carboniferous species.

Genus Modiola.

Modiola lithodomoides,[1] sp. nov. Pl. VIII. Figs. 1 and 2.

Lithodomus dactyloides, Huxley and Etheridge's Cat. Foss. Mus. Pract. Geol. 1865, p. 110 (non M'Coy).

Lithodomus dactyloides, R. Etheridge, jun., Mem. Geol. Survey, Expl. 22, Scotland, 1872, p. 43 (non M'Coy).

[Compare,—*Lithophaga lingualis*, Meek and Worthen, Geol. Rep. Illinois, 1868, vol. iii. p. 536, t. 19, f. 1 (and f. 2 ?), (non Phillips).]

Specific characters.—Shell much elongated, and convex anteriorly, compressed posteriorly; beaks quite anterior, and terminal, bluntly pointed; anterior end somewhat narrowed, convex in the umbonal region, and compressed towards the ventral margin; posterior end expanded and wider than the anterior, much compressed laterally; dorsal margin straight; ventral margin curved, at the anterior end convex, gently and slightly concave in the middle, and convex at the posterior end; the valves are gibbous along a line nearest to the dorsal margin, backwards to the posterior end, but which gradually descends until it becomes lost in the expanded portion of the latter; the greatest convexity is about the middle of the shell, but if anything a little anterior; the shell is thin, and has a surface ornamentation consisting of exceedingly fine, closely set, and regular lines, with, here and there, an occasional wrinkle, especially towards the ventral margin.

Observations.—This is an exceedingly graceful and well-marked shell. The specimens which have come under my notice vary a little amongst themselves; thus, in the majority the dorsal margin is straight, but in one specimen there is a tendency to become a little arched. The amount of the concavity in the central part of the ventral margin and the expansion of the posterior end are also variable. From

[1] From its general resemblance to the genus *Lithodomus*.

Modiola lingualis, Phil.,[1] which it very much resembles, *M. lithodomoides* may be distinguished by the difference in size, by the convex ventral margin of the former, by the much more bluntly rounded form of the beaks in the present species, and probably finer, closer, and more regular surface ornamentation. *M. lithodomoides* resembles *M. elongata*, Phil.,[2] but is not carinate, and the dorsal margin is not curved. Under the provisional name of *Lithophaga lingualis* (Phillips) Messrs. Meek and Worthen have described[3] and given two figures of a shell from the Keokuk group of the Illinois and Indiana Sub-carboniferous series, one of which (pl. 19, fig. 1) appears to be very near our shell, if not identical with it, and certainly distinct from Phillips' *M. lingualis*, from which it differs by its more obtuse umbones and straighter dorsal margin, and, as indicated by its describers, by its much greater size. I am supported in this view by the valued opinion of my friend Mr. G. Sharman. *M. lithodomoides* shows no trace of the radiating lines of *Lithodomus dactyloides*, McCoy.

The following are the approximate measurements of the seven specimens before me:—

1.	Length 1 inch 1½ lines,	width 3½ inches	Longnor, Derbyshire.
2.	,, 9½ ,,	,, 2 ,, 3 lines	,, ,,
3.	,, 11½ ,,	,, 2 ,, 2 ,, (broken)	,, ,,
4.	,, 9½ ,,	,, 3 ,,	Trearne House, Ayrshire.
5.	,, 7 ,,	,, 2½ ,,	,, ,,
6.	,, 6¼ ,,	,, 1 ,, 10 ,,	Glen Lora, Renfrewshire.
7.	,, 11 ,,	,, 3 ,, 3½ ,,	Beith, Ayrshire.

Localities.—Longnor, Derbyshire, in Carboniferous Limestone (3 specimens, Coll. Mus. Pract. Geol.); Beith, Ayrshire, in Carboniferous Shale (1 specimen,[4] Coll. Edin. Geol. Soc.; I am much indebted for the loan of this specimen to the kindness of the Society's Curator, Mr. J. Henderson); Lora burn, Glenlora, and Lochwinnoch, Renfrewshire, from Shale resting on the lowest of six Limestones (I am informed by my colleague, Mr. R. L. Jack, F.G.S., that these occupy the position of the lowest or Howrat Limestone, L. Carboniferous Limestone group); and Quarry, a little north of Trearne House, Gateside, Beith, Ayrshire, from Shale in connexion with the Lower Limestone (Main), L. Carb. Limestone group (2 specimens, Coll. Geol. Surv. Scotland, collected by Mr. A. Macconochie).

Pisces.

Genus Petalorhynchus, Agassiz.

The peculiar palatal tooth represented by Pl. VIII. Figs. 3 and 4, was obtained, with another specimen, by Mr. James Bennie (after whom I beg to name the species) at Shiells Quarry, near E. Kilbride. I was for some time in doubt as to the proper genus to which the two specimens in Mr. Bennie's collection should be referred, and was inclined to regard them as perhaps typical of a new genus, for which

[1] Geol. York, 1836, vol. ii. p. 209, t. 5, f. 21.
[2] See p. 210, t. 5, f. 24.
[3] Geol. Rep., Illinois, vol. iii. p. 536, t. 19, f. 1 and 2.
[4] Presented to the Society by Mr. Armstrong.

I had in MS. adopted the name *Hoplodus*;[1] but at the suggestion of Mr. W. Davies, of the British Museum, who was kind enough to assist me in their comparison with specimens of different species of *Petalorhynchus* in the Museum collection, I have referred them to the latter genus. Independently of the peculiar form and relatively greater development of the posterior face as compared with the anterior, the teeth resemble the genus *Petalodus*, as well as that to which they are referred, in the cutting edge of the crown, smooth polished surface, and entire and undivided root; but at the same time one of the peculiarly distinctive characters of *Petalorhynchus* is not visible—the non-extension of the transverse imbricating folds to the lateral angles of the crown.

Petalorhynchus ? Benniei, sp. nov. Pl. VIII. Figs. 3 and 4.

Sp. chars.—The general outline is somewhat hoof-shaped, with the exposed portion of the tooth consisting of two parts, one, a vertical portion forming the cutting edge of the tooth, the other part, nearly at right angles to this, and from the under surface of which proceeds the undivided root (Fig. 3, *r*). The superior margin or cutting edge (Fig. 4, *c, c*) is convex in outline, minutely crenulate-striate, and with a single, sharp, and central denticle; the surface of both portions of the tooth is smooth and polished. The anterior face of the vertical portion of the crown is slightly convex, the posterior face concave, and descends lower than the former, to its union with the horizontal portion. The inferior margin of the anterior face of the crown is formed by a ridge, with scarcely any visible imbricating folds or bands, and is unsymmetrical with the superior margin or cutting edge. The horizontal portion of the crown is notched at its free edge, or has a re-entering angle in it. The root proceeds as a single fang from the whole of the under surface of the horizontal portion.

Obs.—Mr. W. Davies has very kindly afforded me the following information:—A similar tooth formed one of a collection brought under the notice of the Geological Section of the Bradford Meeting of the British Association the year before last (1873) by Mr. W. Horne, of Leyburn, from the Yoredale Limestone of Wensleydale, Yorkshire.[2] Mr. Davies and Mr. Horne had, before the meeting referred to, discussed the probability of this tooth having been the entire dental armature of an upper or lower jaw, or whether it might have been one of several teeth appertaining to the same mouth. Mr. Davies is also much impressed with its resemblance, externally, to the uncovered teeth of the Parrot fishes generally, but more especially to the *Diodons*; but, as the fish which bore this tooth was undoubtedly a Selachian, and the structure of the tooth, within the mouth, so different to that of the *Diodons*, it can have no affinity with these recent fishes, although very suggestive of a Selachian with a similar form of mouth. A specimen of *P. Benniei* is in the British Museum Collection, from Beith, presented by Mr. Craig.

[1] ὁπλή, *a hoof.*

[2] *Brit. Assoc. Reports*, T. S. p. 84 (short abstract only).—I take this opportunity of expressing my thanks to Mr. Davies for much kind assistance rendered me at the British Museum on several occasions.

The crenulate striations along the cutting edge of the tooth are also continued along the edges of the central denticle.

Locality.—Shiells Quarry, near East Kilbride, Lanarkshire, from shale connected with the main Limestone, Lower Carboniferous Limestone Group. Collected by Mr. James Bennie, after whom the species is named, and to whom I am indebted for an opportunity of describing it.

Genus Petalodus.

Petalodus ? lobatus, sp. nov. Plate VIII. Figs. 5 and 6.

Sp. chars.—Tooth small; crown thin, flattened; superior margin with an angular outline, gradually sloping away to the lateral angles, and divided into numerous lobes or denticles, of which the middle one is the largest (the sides of the specimen are broken, but on one side the central denticle there are six perfect, and the remains of a seventh broken denticle, whilst on the other side there are only three preserved); surface of the crown smooth, and highly polished; anterior face convex, with the coronal ridge formed of three or more imbricating bands or folds, extending from the lateral angles of the tooth in a graceful curve to a central point about opposite the large middle denticle of the cutting edge. Posterior face a little concave, with the coronal bands more strongly marked, wider apart, more numerous, and further from the cutting edge than on the anterior face. The lobes into which the cutting edge is divided diminish successively in size from the central large one to the lateral angles; the former is acute and pointed, the latter are bluntly rounded, and all are entire and non-serrate. The root is long and pointed; on the anterior side convex in the middle, concave at the sides.

Obs.—This elegant little tooth appears to partake in some respects of characters appertaining to the genera *Petalodus* and *Ctenoptychius*. It resembles the former in the arched form of the cutting edge of the crown, acute lateral angles, and in the arrangement and degree of development of the imbricating bands forming the inferior margin of the crown, especially in those of the posterior face descending lower than those of the anterior, but in the deep lobation of the cutting edge approaches the latter, especially the tooth known as *C. serratus*, Owen,[1] in which, however, each lobe or denticle is serrated, whereas in the present species they are all entire. It is in this lobation that *P. lobatus* departs from the *Petalodus* type; for in the species comprised in this genus the cutting edge appears to be entire and merely serrate or crenate, not lobed. *P. lobatus* has a general resemblance to *Ctenoptychius apicalis*,[2] Ag., but in this species, as figured by Agassiz, the denticles are larger and the general form of the tooth is different. A species described by Messrs. Newberry and Worthen, from the Coal-measures of Indiana, as *C. semicircularis*,[3] is very nearly allied to our fossil, but the section is semicircular, the lobes or denticles less in number, and either acute or rounded in outline, whereas in *P. lobatus* they are all, with the exception of the central one, rounded, and are more numerous. The

[1] M'Coy's *Brit. Pal. Foss.* p. 636, t. 31, figs. 21, 22, and 23.
[2] *Poiss. Foss.* Atlas iii. t. 19, figs. 1 and 1*a*.
[3] *Geol. Surv. Rept.* Illinois, vol. ii. p. 72, t. 4, figs. 18 *a.* and *b.*

anterior and posterior faces of *C. semicircularis* "are nearly of equal height, the anterior sometimes showing a basal ridge as in *Petalodus*."[1] In *P. lobatus*, on the contrary, the imbricating ridges on the posterior face are much lower than those on the anterior.

Locality.—Old Quarry on Crosshouse Farm, near East Kilbride, from shale above the main Limestone, Lower Carboniferous Limestone Group. In the cabinet of, and collected by Mr. James Bennie.

EXPLANATION OF PLATE VIII.

Fig. 1. *Modiola lithodomoides*, R. Eth., Jun., Longnor, Derbyshire; nat. size. Coll. Museum Pract. Geol.

Fig. 2. *Modiola lithodomoides*, R. Eth., Jun., Beith, Ayrshire; nat. size. Coll. Edinb. Geol. Soc.

Fig. 3. *Petalorhynchus ? Benniei*, R. Eth., Jun., Shiells Quarry, near East Kilbride; view of posterior face, × 2.

Fig. 4. *Petalorhynchus ? Benniei*, R. Eth., Jun., Shiells Quarry, near East Kilbride; view of anterior face, × 2.

Fig. 5. *Petalodus ? lobatus*. R. Eth., Jun., Crosshouse, near East Kilbride; view of anterior face, × 4.

Fig. 6. *Petalodus ? lobatus*, R. Eth., Jun., Crosshouse, near East Kilbride; view of posterior face, × 4.

Correction.—In my "Notes on Carboniferous Lamellibranchiata" (Geol. Mag. 1874, Dec. II. Vol. I.) an error occurs in the description of Plate XIII. (pp. 305-6). For "slightly enlarged," and "natural size," read, *all figures enlarged twice the natural size.*

II.—Contributions to the Study of Volcanos.

By J. W. Judd, F.G.S.

(*Continued from page* 214.)

The Island of Ischia.

PERHAPS no district of equal area could be named in which so many instructive illustrations of volcanic action may be witnessed as the beautiful island of Ischia. Although only about six miles long by four broad, yet this island exhibits a great central volcanic mountain,—named "Epomeo"—surrounded by numerous parasitical cones and craters, which, alike in their features and their products, present the most interesting variations.

After the well-known descriptions which have been given of the island by Sir William Hamilton, Scrope, Daubeny, James D. Forbes, Scacchi, and many other observers, and the more complete treatises of Signor Ferdinando Fonseca and Herr C. W. C. Fuchs, dealing respectively with its palæontological and petrological features, any further account of its geology may seem to be unnecessary. But a study of the physical features presented by the island, aided by the light thrown upon them by the numerous valuable researches above alluded to, appears to me to lead to a more complete realization of the nature, mode of action, and succession of the forces to which the production of those features was due, than has as yet been published, and enables us to reconstruct, in a more complete manner than has been hitherto attempted, the geological history of the island. In the following descriptions, therefore, I shall pursue the chronological method, and, beginning with the oldest formations, gradually pass to those of more recent date, until we at last reach those the production of which is noticed in historical records.

[1] *l.c.* p. 73.

The island of Ischia, like those of Vivara, Procida, and Nisita, is merely an outlying portion of the Campi Phlegræi of Naples; and the conclusions to which we are led concerning the nature and age of the tuffs and lavas of the island we are especially describing, are almost equally applicable to those of the whole district. The two principal volcanos of this area are Vesuvius (including under that name the more ancient Somma as part of the same mountain) and Epomeo; the former of which consists of a central cone within a semi-circular crater-ring, composed of trachytic-tuffs enveloped by lava and agglomerates of leucitic basalt, which have been the products of all its later eruptions; the latter is a ruined tuff-cone, surrounded by numerous parasitical vents, the lavas and fragmentary materials produced by which have all been of trachytic character.

A line drawn through Epomeo and Vesuvius would, if produced, strike the volcanic region of Monte Vultur in one direction, and that of the Ponza Islands in the other; and the numerous cones, crater-rings, and crater-lakes of the Campi Phlegræi all appear to be arranged along lines parallel to this series of grand volcanos.

We can scarcely doubt, therefore, that this linear and parallel arrangement points to the existence of a corresponding series of subterranean fissures, by means of which the igneous products, whether of recent date or belonging to older geological periods, were enabled to reach the surface.

The oldest portions of the volcanic rocks of Ischia are unquestionably the series of pumiceous tuffs of a greenish colour which make up the great central cone of Epomeo. That this tuff has been formed from an ordinary trachytic lava, through the distension and dispersion of portions of its mass at periods of eruption by the imprisoned gaseous and liquid materials, there is clear proof afforded in its general characters, and chemical composition. We may indeed call this tuff the "froth" of trachyte, and compare its relations to that rock with those which subsist between the wave and the wreaths of foam driven from its summit. The following analyses illustrate the composition of these tuffs of Epomeo, and prove its general identity with those of the Phlegræan fields, of which numerous analyses have been published:—

	Analysis of the Green tuff of Epomeo by C. W. C. Fuchs, 1872.	Analysis of the same by H. Abich, 1837.
Silica	54·69	54·57
Alumina	20·00	17·93
Ferric Oxide	3·13	} 5·49
Ferrous Oxide	2·26	
Lime	2·17	0·77
Magnesia	0·70	0·77
Manganese	0·02	—
Potash	4·77	5·23
Soda	0·28	6·40
Phosphoric acid	0·021	—
Water and loss	11·61	8·19
	99·65	99·35
Specific gravity	2·17	2·52

Concerning the conditions under which this green tuff of Epomeo was formed, we are fortunately not left in any doubt. It consists entirely, as we have seen, of pumiceous fragments, mingled with broken crystals of sanidine and numerous plates of black mica; these being the most common of the minerals included in the ordinary trachytes of the district. The mass is often found to contain, moreover, volcanic-bombs, and the proof of the tuffs having been the result of the ordinary explosive action of volcanos is, therefore, most complete. But mingled with these tuffs are found very numerous marine shells, specimens of which I collected up to a height of 1846 feet on the slopes of Epomeo, and they have been recorded as occurring even at still greater elevations. It would seem clear, therefore, that the tuffs must have been accumulated beneath the sea-level, but at such moderate depths as not to prevent the ordinary explosive action, and that disengagement of imprisoned vapour and gas, to which the pumiceous structure is evidently due, readily taking place. In opposition to the view put forward by some geologists,—namely, that lava when poured forth under water gives rise to a totally different series of products from those formed by subaerial volcanic action,—I may point to the fact that these undoubtedly marine tuffs of Epomeo, abounding in shells, offer no essential points of difference from the tuffs of Bagno Secco in Lipari before described, or those of Somma, both of which, as we have seen, contain numerous leaves and other remains of terrestrial plants, and were clearly of subaerial origin.

But in the case of the tuffs of Epomeo we have another interesting proof of its submarine mode of origin. The tuffs are sometimes interstratified with "marls," "clays," and white calcareous rocks of a chalk-like aspect. The interesting analyses of these, however, by Fuchs, show that they are all formed from the volcanic tuffs by ordinary aqueous erosion, aided to some extent by the passage through the mass of gases and vapours, and the ordinary action of organic beings living on the sea-bottom, especially of the mollusca, in separating the carbonate of lime. In illustration of this statement, we may quote the following analyses:—

	(*a*)	(*b*)	(*c*)	(*d*)
Silica	59·88	58·31	46·28	57·20
Alumina...	17·28	19·79	12·71	15·71
Ferric Oxide	5·06	2·86	4·46	5·51
Ferrous Oxide ...	2·30	2·11	2·14	2·64
Lime	1·69	0·70	11·27	1·16
Magnesia	0·80	0·81	2·17	2·68
Manganese	trace	—	—	—
Potash	6·43	6·29	2·58	3·19
Soda	2·97	2·88	0·82	1·01
Water	3·69	7·24	8·67	10·71
Phosphoric Acid ...	0·043	—	—	—
Carbonic Acid ...	—	—	8·13	—
	100·14	100·99	99·23	99·81

(*a*) represents the composition of the so-called marl of Epomeo, which is very largely dug, and both at Casamicciola and Naples, to which latter place it is largely exported, used for making tiles and pottery; (*b*) is the analysis of the concretionary nodules resembling the masses, often septariform, which abound in so many clays and marls; (*c*) a similar fine-grained white rock, but containing 18·44 per cent. of carbonate of lime; and (*d*) the composition of the residue of the same rock after the carbonate of lime, doubtless owing its presence to organic remains, has been removed by acetic acid.

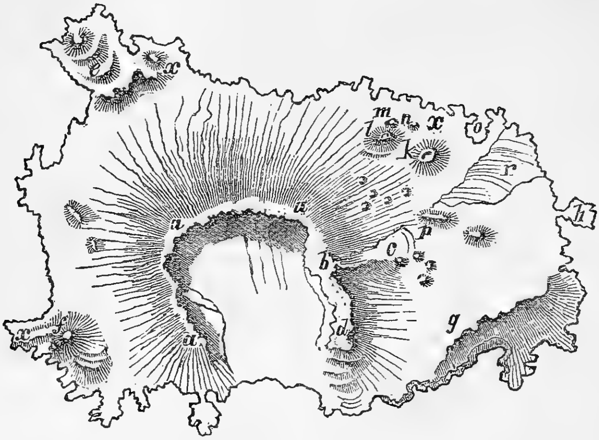


FIG. 14.—PLAN OF THE ISLAND OF ISCHIA.

a, a, a, The semi-circular Crater-ring of Epomeo.
b, c, d, M. Vetta, M. Trippia, and M. Garofali; portions of lavas proceeding from central crater.
e, f, g, h, Plateaux composed of old lavas.
k, Montagnone
l, Monte Rotaro
m, Monte Tabor
n, Castiglione
o, Lago di Bagno
p, The Cremata
r, Lava of the Arso
(*k*–*r*) Products of the most recent eruptions.
x, x, x, Raised beaches.

The mountain of Epomeo or S. Nicola attains a height, according to the measurement of Scacchi, of 2608 feet. The mass of tuffs of which it is composed constitutes a great semi-circular wall surrounding a vast crater (see Plan of the Island, Fig. 14), about two miles in diameter, at the bottom of which are situated the villages of Fontana and Meropano. The depth of this great crater, of which the walls unsustained by the binding courses constituted by lava-streams, or the buttresses formed by dykes, are in a state of great ruin from denudation, is about 2000 feet. At its eastern extremity the great wall bounding the crater on its northern side is 2215 feet above the sea, and several of its highest peaks are in this part over 2500 feet; on the west and south-west this crater-wall is found to gradually decline in elevation, until above Serrara it is only 1276 feet. On its south, south-east, and eastern sides the crater-rim has been almost completely destroyed, owing to causes which will be presently noticed.

On its outer slopes the great cone of Epomeo is made up of fine-grained, well-stratified tuffs, dipping outwardly from the centre, and alternating with beds of so-called clay, marl and chalky-marl, produced by aqueous and organic agencies from the igneous products. But in its central parts, and within the great crater, the mass is composed of much coarser materials, and includes angular blocks and bombs of large size.

The causes of the destruction of the vast crater of Epomeo we have not far to seek. Its walls being wholly built up, as we have seen, of loose tuffs, it is evident that the weight of any great mass of lava rising through the vent would inevitably, if it did not force an exit for itself nearer the base of the mountain, carry away the weakest side, and thus breach the crater. That the crater of Epomeo was thus breached on its eastern side we have very clear evidence. It is true that the great streams of lava which have flowed from this side of the crater down the slope have been cut up into a number of isolated plateaux by aqueous erosion, but a comparison of the slopes and elevations of these surviving portions furnishes us with the clearest evidence of their former continuity. Thus Monte Vetta exhibits the great bed of trachyte, which is nearly 200 feet thick, at an elevation of 1651 feet; in Monte Trippia it rises to 1341 feet; while in the hill of Moscardine it is only about 900 feet. In Monte Garofali we find another great mass, perhaps a portion of the same sheet. And all have a similarly inclined position dipping from the great central crater of Epomeo.

All the lavas of Ischia, from the oldest to those more recent ones which we shall hereafter describe, are of trachytic character; but although their ultimate chemical composition is almost identical, they nevertheless offer some very interesting peculiarities with respect to the minerals into which their elements are combined. The trachytes of Ischia are made up of a crystalline base composed of both orthoclastic and plagioclastic felspar, throughout the mass of which large and brilliant crystals of sanidine, with smaller ones of sodalite, hornblende, mica, mellilite, magnetite, and ilmenite are scattered in various proportions. Sometimes the whole passes into a compact rock; at others we find a stony base containing the sanidine and other crystals; while occasionally the base becomes vitreous and the rock passes into a porphyritic obsidian ("obsidian-porphyry" or "pitchstone-porphyry"). Sometimes again, as in the case of the quartz-trachyte or Liparites of Ponza, Lipari, etc., the true trachytes of Ischia exhibit compact and vitreous portions combined in alternating bands.

As examples of the composition of the coarsely crystalline light-coloured trachytes of Ischia, we may cite the following analyses from Fuchs and vom Rath:—

	Monte Vetta.	Scanella.	Scarrupata.		Marecocco.
Specific gravity ...	2·45	—	I.	II.	2·43
Silica	61·87	59·12	62·95	65·75	61·49
Alumina...	18·33	21·46	18·26	17·87	20·02
Ferric Oxide	3·23	2·68	4·46	4·25	3·11
Ferrous Oxide ...	2·51	2·72	—	—	2·72
Lime	2·11	2·16	0·84	1·33	1·88
Magnesia	0·65	0·84	0·63	0·52	0·52
Potash	6·51	7·66	6·06	3·48	7·13
Soda	5·07	3·78	7·17	5·36	3·39

I have omitted from these analyses the small proportions of sodic chloride, phosphoric acid, etc., which they contain.

As examples of the compact and dark-coloured trachytes, we may notice the following:—

	Monte Campagnano.	Monte dell' Imperatore.	Punta della Cima.
Silica	63·06	61·05	61·55
Alumina	18·32	18·35	17·81
Ferric Oxide ...	3·22	4·21	3·01
Ferrous Oxide ...	—	2·12	2·60
Lime	2·53	2·05	1·69
Magnesia	0·93	0·90	0·47
Potash	7·52	5·28	7·51
Soda	3·08	5·94	4·08
Specific gravity ...	2·48	2·53	2·46

These trachytes are all apparently of considerable antiquity. That of Monte Vetta forms, as we have seen, a number of isolated plateaux, once a connected lava-stream, which breached the great crater of Epomeo on its western side. The other lavas also form plateaux of ancient date, which flowed from some portion of Epomeo, or from lateral cones on its flanks. The original points of outburst of these lava-streams can now, however, be no longer traced, so greatly have they suffered from denudation. Some of these lavas, like those of Scarrupata and Monte Vetta, are remarkable for containing sodalite, as shown by vom Rath. Others, like those of Monte Marecocco, etc., are distinguished by the presence of mellilite. The compact lava of Monte Campagnano in places becomes vitreous, and passes into obsidian, and it occasionally exhibits a banded or ribboned structure, veins of vitreous alternating with others of stony lava.

These lava-streams frequently cap masses of tuff, and are sometimes interbedded with such materials. In some cases these tuffs are made up of fragments of trachyte distended by gas; in others they are decidedly pumiceous, and have been evidently formed from a glassy rock. As an example of the former, we may cite the trachyte tuff of Punta S. Angelo; of the latter, the pumice-tuff and pumice of Monte Vico:—

	Trachyte-tuff of Punta S. Angelo.	Pumice-tuff of Monte Vico.	Pumice of Monte Vico.
Silica	53·71	54·02	60·06
Alumina	16·35	18·18	16·42
Ferric Oxide ...	2·82	3·64	3·01
Ferrous Oxide ...	2·19	2·23	2·33
Lime	1·38	2·01	1·37
Magnesia	0·55	0·79	0·40
Potash...	6·73	3·86	8·05
Soda	2·53	1·71	3·20
Water	14·43	14·30	5·27

The whole of the rocks which we have now described as occurring in Ischia are of such ancient date that they have suffered very greatly from the denuding action of subaerial forces. The lavas which now cap the highest hills must have originally flowed along the bottoms of valleys, the sides of which have been since removed. Streams have cut ravines hundreds of feet in depth through the hardest lava-beds, leaving isolated portions of them forming high plateaux; the sea has eaten into the coast-line, causing the hardest and most solid masses to project as great promontories; and landslips, probably resulting from earthquakes (to which the district is particularly liable), have done much in bringing the central cone of Epomeo into its present ruinous condition. But vast as are the changes which have been produced by denuding forces upon these older portions of the island, yet that these latter have all been formed within a period which is, *geologically* speaking, very recent, is shown by the fact that, with one or two exceptions, all the fossil shells found in the tuffs (now raised to a height of 2000 feet in Epomeo) are still living in the neighbouring Mediterranean.

At various points, however, around this old extinct volcano of Epomeo, and especially on its north-eastern side, we find a number of cones and lava-streams, which by their fresh appearance are seen to be clearly of much more recent date; and of some of these the formation is recorded in historical documents. The relations of the ruined central volcano of Ischia, with its lava-streams cut up by denuding action into isolated plateaux, to the surrounding cinder-cones and lavas, are precisely similar to those which were so long ago shown by Mr. Scrope to subsist between the three great volcanos of Central France and the numerous "puys" which surround them. The series of efforts to which the Italian group of volcanos owes its origin must evidently have taken place within a much shorter geological period than those of Central France, which go back as far as the Older Miocene period; while the latter are, however, apparently quite extinct, the former are probably only passing through an interval of repose separating periods of paroxysmal violence.

Of the later-formed volcanic vents ("puys") of Ischia, the principal are Montagnone, Monte Rotaro with Monte Tabor, the Castiglione, the beautiful lake-crater known as the Lago del Bagno, and the modern cinder-cone of the Cremate, of the formation of which in 1301 we have the clearest historical records.

Montagnone is a very perfect cone rising to the height of 1084 feet, and presenting at its summit a crater of oval form, the bottom of which is 760 feet above the sea-level. The cone is almost completely made up of trachytic scoriæ and blocks of trachyte of all sizes. Trachytic lava of extremely viscid character appears also to have flowed from it, one narrow stream carrying away the eastern side of the crater and flowing down towards Bagno, while a wider current has broken down part of its northern side and cascaded down a steep slope, exhibiting a remarkable banded structure where the tension of the very imperfectly liquid mass has evidently been most violent. Neither of these streams, however, was able to flow far, nor to spread itself beyond the slope of the mountain. Many of the Ischian lavas, indeed, appear to have been exuded in a condition of such extreme viscosity that they accumulated immediately around the vent in vast hummocky masses; and in some cases it is difficult to decide whether we are dealing with the highly scorified surface of a solid mass of lava, or the agglutinated fragments of similar materials. Several active fumaroles still exist about Montagnone, and if we may be permitted to judge from the much less weathered condition of its rocks, almost destitute of soil and vegetation as they are, we should pronounce this cone to be of even more recent date than Monte Rotaro.

This latter cone is situated on the western side of Montagnone, and is so contiguous to it that in their lower portions the slopes of the two hills blend with one another. The highest point of the beautiful cone of Monte Rotaro is on its S.S.W. side, and is 982 feet above the sea; the lowest point of the crater-ring, on its western side, is 677 feet; while the floor of the crater is only 570 feet. Nothing can be more striking than the contrast between the appearance of Rotaro and Montagnone, the latter being remarkable for the barrenness of its bristling surface of lava, while the former is completely clothed with the most luxuriant trees and shrubs. The interior of the crater of Rotaro, especially, presents the most picturesque appearance, offering some analogy with the well-known much-larger crater of Astroni, near Naples. The extraordinary fertility of the soil formed by the decomposition of the volcanic rocks, combined with the sheltered situation, and perhaps also the subterranean heat (for hot vapours issue from the rocks at a number of points), have caused the ordinary shrubs of the Mediterranean area to assume a luxuriance unknown to them elsewhere. It is even said that the abnormal development of certain forms growing in this natural hot-house is so great as to make the species in some cases difficult of recognition.

The cone of Monte Rotaro is made up of an agglomerate containing blocks of all sizes of the ordinary sanidine-trachyte, more or less scoriaceous, and sometimes becoming pumiceous. Among the blocks are many composed of sanidine-trachyte with a vitreous base (pitchstone-porphyry), the glass being of a jet black colour, and the brilliant white crystals of sanidine scattered through it giving the rock a most striking appearance. When the glassy base of this "pitchstone-porphyry" or porphyritic obsidian is distended by gases, it passes into pumice, which still contains entangled among its fibres the fine crystals of sanidine, showing clearly that these latter must have been formed *within* the volcano, and not during the progress of the cooling of the lava.

It must of course be borne in mind that, as was clearly pointed out by Abich, we have two distinct series of obsidians and pumices, the one corresponding to the *quartz*-trachytes, and the other to the *ordinary* trachytes. Of the first of these we have already given many illustrations in describing the Lipari Islands; of the latter we can perhaps nowhere study more interesting examples than in Ischia. All volcanic rocks may pass into the vitreous condition, but their tendency to do so seems to be directly related to the proportion of silica which they contain. Thus by far the most abundant obsidians are those which correspond to the highly acid lavas, the quartz-trachytes or Liparites; next in order, but far less abundant, are the obsidians like those of Ischia, which are of the same chemical composition as the ordinary trachytes; while the basic lavas only very rarely assume the glassy condition (tachylite, etc.). The following analyses of an Ischian pumice by Abich, and of the "obsidian" of Monte Rotaro by Fuchs, may be compared with those of the more acid glasses of Lipari, which analyses have been already given on page 62.

	Pumice of the Island of Ischia.	Obsidian of Monte Rotaro.
Silica...	62·29	60·77
Alumina ...	16·89	19·83
Ferric Oxide ...	—	4·14
Ferrous Oxide...	4·15	2·43
Lime...	1·24	1·63
Magnesia...	0·50	0·34
Potash ...	3·98	6·27
Soda...	6·21	4·90
Water, etc.	3·89	0·24
Specific gravity ...	2·4172	2·44

The bottom of the crater of Monte Rotaro is a small level plain about 70 yards in diameter; around this the walls of the crater rise to heights varying from 400 to 100 feet. The irregular height of the crater-walls appears to be the result of denudation; for though several lava-streams have issued from it, notably one on its southern side, yet the crater seems to have been reformed subsequently to the outflow of the last of them. Indeed, as we shall now proceed to show, the streams of lava of the latest eruptions of Monte Rotaro appear to have proceeded from its base, and not from its summit, the crater remaining unbreached.

On the northern slope of Monte Rotaro are situated two small ruined cinder-cones, which bear to that volcano the same relation which it does to the central mass of Epomeo. These smaller and more modern vents are Monte Tabor and the Castiglione. (See Fig. 15.) The little cone of Monte Tabor is made up of an agglomerate of

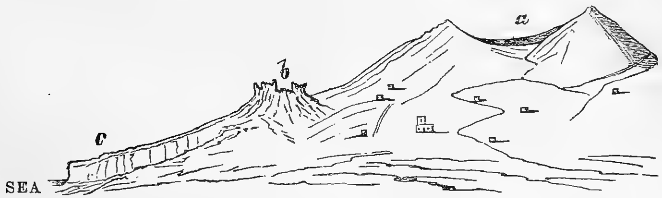


Fig. 15.—Monte Rotaro with Monte Tabor at its foot, as seen from Casamicciola. *a*, the crater of Rotaro. *b*, the ruined cone of Tabor. *c*, the lava-stream flowing to the sea and well exposed in a series of quarries.

blocks, some of which are of great size, and are always more or less scoriaceous. Mingled with the scoriæ are many fragments of the ordinary tuffs of Ischia, and of the same peculiar trachyte which has flowed from the cone. These are often burnt to a bright-red colour. Near the south foot of Monte Tabor an old "stufa" occurs. Monte Tabor is evidently the remains of a small cone thrown up at the time of the issue of a lava-stream from the foot of Monte Rotaro, by the flow of which its northern side was swept away, while many of its lighter materials have also been removed by atmospheric denudation.

The lava-stream which flowed from the cone to the sea is very extensively quarried, and thereby favourably exposed for study. The rock consists of a sanidine-trachyte of a pink, reddish, greyish, bluish, or greenish tint. The pink colour of certain parts of the rock is due to numerous crystals of Mellilite (Humboldtilite). The sanidine crystals of this rock are usually small, and some of oligoclase are scattered through the basis of the rock. The other minerals contained in the rock are magnetite, hornblende, mica, and a little augite. This interesting rock has been analysed by Fuchs with the following result:—

Silica...	62·17	Soda	4·76
Alumina	20·83	Phosphoric Acid	0·024
Ferric Oxide	2·26	Chlorine...	0·25
Ferrous Oxide	2·16	Loss	0·25
Manganese	trace		
Lime...	1·68		101·23
Magnesia	0·45		
Potash	6·40	Specific gravity ...	2·45

The upper surface of this lava-stream is composed of a scoriaceous, almost pumiceous mass, containing porphyritic crystals entangled in it, and often also inclosing blocks of lava and fragments of the older tuffs which have been borne along in its flow. Where it first issues, this upper scoriaceous portion of the lava-stream is not less than 15 feet thick, but it gradually diminishes to a few feet only towards the end of the current.

A little to the east of Monte Tabor another and smaller vent has been opened, which has given rise to another lava that has flowed down to the sea. At its source is the still active stufa known as Acqua Castiglione al mare, the water of which has a temperature of from 160° to 170° F. The lava of Castiglione is a trachyte of darker colour than that of Monte Tabor, and, like it, is exhibited in sections in the cliffs of the island.

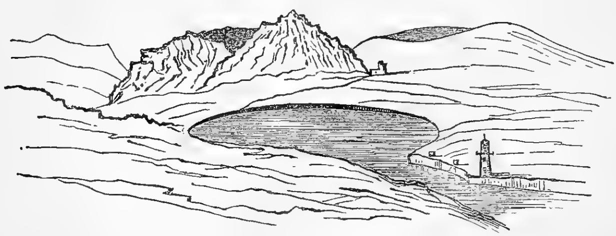


Fig. 16.—The Crater-lake of Lago del Bagno, Ischia, with Montagnone and Rotaro in the distance.

The Lago del Bagno is evidently a small crater-lake; it is of regularly circular form, and about a quarter of a mile in diameter. It has clearly been formed, like the similar craters occupied by lakes in the Campi Phlegræi, by explosive action. A few years ago the tuffs forming the northern margin of this lake were cut through, and the sea-water being thus admitted, a most beautiful basin was formed, within which ships can lie in perfect security; this natural basin now affords by far the best port in the island. (See Fig. 16.)

The recent date of the cones, craters, and lava-streams just described, is proved by their very fresh appearance. It is probable that some at least of them were produced during the outbursts, accompanied by such terrible earthquakes that the inhabitants were compelled for a time to abandon the island, which we know from historical accounts to have frequently taken place. Great eruptions are recorded as having occurred in Ischia about the year 470, between the years of 400 and 352, and in that of 89 B.C., and between 79-81, 138-161, and 284-305 A.D. After an interval of nearly a thousand years, the great outbreak of 1301 took place. The attempts which have been made to identify the various recorded outbursts before the long period of rest, with existing cones and lava-streams, are, it seems to me, at best very conjectural; but that the eruption of 1301 gave rise to the crater known as the Cremate, and the lava-stream of the Arso which flows from it, there is not the smallest room for doubting.

The Cremate is situated in a deep valley in the east side of Epomeo, and constitutes a perfect example of a small volcanic cone which has been breached by the outflow of a great current of lava. By descending the interior slopes of the crater, we find its walls to be composed of the scoriæ derived from the same peculiar trachyte which constitutes the Arso lava-stream. These scoriæ are black cinder-like masses (weathering to a reddish colour), completely filled with the entangled crystals of sanidine and other minerals which occur porphyritically imbedded in the solid lava. Sometimes the lava blocks have a vitreous base, and resemble "pitchstone-porphyry," and in these cases the scoriæ derived from them have a pumiceous character. Alternating with the great masses of agglomerate, the blocks of which are of all sizes, some being very large, are a number of subordinate lava-currents, of the same petrological character as the principal lava-stream. The great lava-current of the Arso has risen from the bottom of the crater of the Cremate, and, sweeping away its western side, has flowed down to the sea, along the line of valley between Bagno and the city of Ischia, a distance of about a mile and a half. The highest point of the Cremate is 763 feet above the sea, the bottom of its crater 528. From this lowest point the lava has boiled up to the height of 597 feet, and here forms a number of ridges composed of blocks set on end and scattered about in the wildest confusion. Thence following the course of the valley, and widening as it approaches the sea, the lava-current forms an extremely rugged *Cheire*, the surface of which is only very scantily clothed with broom, while numerous trees of the well-known Italian stone-pine have sprung up here and there in its hollows. At a number of points nests of specular iron and other products of sublimation from the cooling lava are found, and one vent still exists from which hot vapour continues to issue.

The accounts of the great eruption of 1381 which have come down to us are of a very meagre character; that of Pontanus having been written in 1538, and that of Marenta in 1559.

The products of this last eruption in Ischia present many features of the highest interest to the geologist. The rock of the Arso lava-stream is decidedly more basic in character than any other rock in the island. It does not, however, fairly fall within the class of lavas intermediate between the trachytes and basalts, to which Abich gave the name of "trachy-dolerite," and to which more modern writers apply the term "andesite." The basis of this lava is of a very dark grey, almost black colour, and consists of an amorphous dark-coloured magma, in which crystals of orthoclastic and plagioclastic felspars are imbedded. Scattered in great abundance through the mass are large crystals of sanidine, which, as Fuchs has shown, present some very anomalous characters. With these occur, sometimes in great abundance, crystals of hornblende, augite, mica, and magnetite, and irregular grains of olivine. A very similar rock occurs, as we have seen, in several of the Lipari Islands.

In illustration of the composition of the peculiar lava of the Arso, I may cite the analyses made of it by Abich and Fuchs, and that of the cinders of the Cremate by the latter author.

	Arso lava. Abich.	The same. Fuchs.	Cinders of Cremate. Fuchs.
Silica	60·80	57·73	54·83
Alumina	17·21	17·85	20·17
Ferric Oxide	3·55	4·44	4·77
Ferrous Oxide	1·29	3·90	3·86
Lime	1·43	3·65	4·12
Magnesia	2·07	1·77	1·93
Potash	7·77	7·65	7·38
Soda	4·64	3·77	3·04

The specific gravity of the Arso rock is according to Fuchs 2·61. Abich estimated the mineralogical composition of the Arso lava to be as follows:—

Felspar	84·45
Olivine	3·61
Augite	9·22
Magnetite	2·72

Ischia contains a great number of hot and mineral springs, at many of which those baths have been erected for which the island is famous. Some of these springs also give off large quantities of carbonic acid and other gases, and a number of stufe from which dry steam issues also occur. These numerous hot springs, etc., testify to the activity of the forces still at work beneath the island; so that a new outburst of these forces, which have now been otherwise dormant for nearly 600 years, may at any time take place.

The effects of subterranean forces in changing the elevation of different parts of the island within periods which are geologically very recent are manifested in the raised beaches of Lacco, Punta St. Alesandro and Punta dell' Imperatore. All of these yield great numbers of shells of the species still existing in the Mediterranean, which are found up to heights of 130 feet above the sea-level.

Alike in the composition of its lavas and tuffs, and in the periods during which its several volcanic formations originated, we find the closest analogy between the island of Ischia and the adjacent Campi Phlegræi; and the study of the former throws much light upon the structure of the latter.

In Ischia we see proofs of a great volcanic cone rising gradually above the sea-level, and, when it had reached its present limit of size, becoming extinct, while lateral outbursts took place on its flanks. Finally, around the ruins of the central pile, sporadic eruptions gave rise to smaller cones and craters, and even these in some cases had their lateral or parasitical cones. The points of resemblance and difference in the course of events and the succession of products in the three great volcanos of southern Italy—Epomeo, Vesuvius, and Vultur—are worthy of the most attentive study and consideration at the hands of the geologist.

(To be continued in our next Number.)

III.—A Chapter in the History of Meteorites.

By Walter Flight, D.Sc., F.G.S.,
Of the Department of Mineralogy, British Museum;
Assistant Examiner in Chemistry, University of London.

(*Continued from page* 226.)

1872, December 12th, 4·53, p.m.—Lexington, Kentucky.[1]

The meteor took a direction S. 45° E., and exploded with a loud noise at an altitude of about 20 miles, the cloud remaining several minutes. The inclination to the horizon was probably not less than 30° or more than 60°. The fragments of the meteorite, which have not yet been found, probably fell 20 or 30 miles N.W. of Lebanon.

A number of meteorites have fallen about this date, and they are separated in a group by an interval of some days from the aerolites of the earlier and later days of December. The members of this group are:—

1858. December 9th.	Aussun and Clarac, Haute Garonne, France.
1870. December 9th.	Tjabé, Bodgo Négoro, Rembang, Java.
1871. December 10th.	Gœmorœh, near Bandong, Java.
1836. December 11th.(?)	Macao, Brazil.
1872. December 12th.	Lexington, Kentucky.
1795. December 13th.	Wold Cottage, Thwing, Yorkshire.
1798. December 13th.(?)	Krakhut, Benares, India.
1803. December 13th.	Mässing, Eggenfeld, Bavaria.
1813. December 13th.	Luotolax, Wiburg, Finland.
1807. December 14th.	Weston, Connecticut.

Found 1872.—Los Angeles, California.[2]

A very brief account is given of a mass of iron weighing 80lbs., which was found at Los Angeles. It is stated that its specific gravity is 7·905, and that, when acted on with dilute nitric acid, the smooth surface exhibits innumerable scales of schreibersite, but that the usual figures are not developed.

[1] D. Kirkwood. *Amer. Jour. Sc.*, 1873, v. 318.
[2] C. T. Jackson. *Amer Jour. Sc.*, 1872, iv. 495.

Found December, 1872.—Neuntmannsdorf, Saxony.[1]

A block of iron, weighing 25lbs., now preserved in the Dresden Museum, was found in 1872, two feet below the surface. As I could meet with no announcement of the constitution of this meteorite, I conceived it possible that it might form a new member of the interesting little group of siderolites to which the Breitenbach, Steinbach and Rittersgrün meteorites belong. I learn, however, from Professor Geinitz, that it is a metallic mass, and that it has been analyzed by Lichtenberger with the following results:—

Iron = 94·59; Nickel = 5·31 = 99·90

It contains no cobalt, carbon, manganese, or uranium. The author states that although it is carefully preserved under a glass shade, a liquid (ferrous chloride) exudes from it, and it shows a tendency to scale off, as the Greenland (Disko) irons do. A more complete investigation of this meteorite will shortly be undertaken.

1873, February 3rd, 9·58 p.m.—Liverpool and Chester.[2]

This meteor, which is described as one of the largest class of detonating meteors, illuminated the whole district which it traversed with one or two prolonged flashes of light at least as powerful as that of the full moon. Owing to the clouded state of the sky, which nearly concealed the moon in many places, the descriptions of its apparent path are nowhere sufficiently determinate to indicate with much precision its real course; the meteor, however, appears to have moved at a lower elevation than is usual with shooting-stars over the north of Staffordshire and Cheshire, passing at a height of less than 40 miles over Crewe, and to have vanished at an altitude of less than 30 miles over a point between Liverpool and Chester; a sound like the loud boom of a distant gun or a loud roll of thunder was heard about three or four minutes after the disappearance of the meteor. The observations of its apparent path show considerable discordance, and it seems that its course may have been more directly from E. to W. The light of the meteor was of a bluish hue, leaving a train of brilliant sparks along its track. It appears to have been visible as far south as Bristol. On the same date, and at the same local time, a very brilliant fireball was seen in Australia.

1873, June 17th, 8·46 p.m. (mean Breslau time).—Proschwitz, near Reichenberg, Bohemia [Lat. 50° 40′ N.; Long. 14° 31′ E.][3]

A brilliant meteor was seen about half an hour after sunset, and in bright twilight, over the whole of the Eastern area of Germany and in Austria; the train remained visible for a quarter of an hour, which enabled the astronomer of the Breslau Observatory to measure

[1] *Amer. Jour. Sc.*, vi. 237.—*Sitzungs-Ber. der Isis zu Dresden*, 1873, 4.

[2] *Brit. Assoc. Rep.*, 1873, Obs. Luminous Meteors, 353 and 364.—*Brit. Assoc. Rep.*, 1873, Obs. Luminous Meteors, 376.—*English Mechanic*, 1873, 171.

[3] G. von Niessl. *Astronom. Nachrichten*, lxxxii. 161. (No. 1955).—J. G. Galle. *Sitz. Meteorolog. Section der Schles. Gesell. für vaterländische Cultur*, 1873, December 17th.

the position of two points along its course. It was observed in Saxony, Thuringia, Brandenburg, Mecklenburg, Pomerania, West Prussia, and in many parts of Austria as far as Hungary; and the report of the explosion was heard in the Hirschberger Thal and along the Riesengebirge range. The explosion appears to have taken place near the Bohemian frontier, at a height of about 4½ geographical miles, nearly over Grosschönau in Saxony and Warnsdorf in Bohemia, the altitude being nearly the same as that at which the cosmical path of the meteorites of Pultusk (1868, January 30th) is believed by Galle to have terminated.[1] According to Niessl, it was seen nearly vertical over the village of Herrnhut in Saxony at the time of its dissolution. The general course of the meteor was from S.S.E. to N.N.W.

Although it does not appear that any fragments of a meteorite are known to have descended in the neighbourhood of Herrnhut, some information was gathered by Prof. Hornstein, of Prague, respecting a very remarkable form of matter which is stated to have fallen at the time of the flight of the meteor. According to an account communicated to the *Reichenberger Zeitung* by the Head Master of the School at Proschwitz, the meteor was seen to explode in the zenith at the time stated, and some of the burning fragments of the meteor fell in that village, one of them on the high road not far from him. It was of about the size of a fist, and continued to burn, emitting a blue light and an odour like that of sulphur, until the flame was extinguished by the villagers stamping it out with their feet. This rough treatment reduced the mass to small pieces, which, mixed with sand and dust, had the appearance of a slag, and were not larger in size than a pea. A stone, a fragment of porphyry, which happened to be selected by one of the bystanders to extinguish the flame, together with some of the above-mentioned fragments, was examined by Websky and Poleck, by whom the substance was pronounced to be pure sulphur.

If this burning mass actually traversed our atmosphere, the occurrence is of peculiar interest, as being one of the very few instances where sulphur in the separate elementary condition has been found as a meteoric substance. Chladni, in his *Feuer-Meteore*,[2] refers to a statement in the *Theatrum Europæum*, vol. iv. p. 399, that in June, 1642 (?), sulphur fell at Magdeburg, and at Lohburg four miles distant; one mass, the size of a fist, striking the roof of the castle. Galle, in his memoir *Ueber den gegenwärtigen Stand der Untersuchungen ueber die gelatinösen sogenannten Sternschnuppen-Substanzen*, published in the year 1869, cites a paper by von Hoff,[3] describing a substance which was found on the 6th September, 1835, between Friemar and Gotha during a star-shower. It smelt like liver of sulphur, and when held in the hand melted to a thick liquid, which evaporated, diffusing a strong odour like that of burning sulphur and phosphorus. Another sub-

[1] J. G. Galle. *Naturw. Abh. zu den Schriften der Schles. Gesell.*, 1868, 79.
[2] E. F. F. Chladni. *Ueber Feuer-Meteore.* Vienna, 1819. Page 367.
[3] K. E. A. von Hoff. *Pogg. Ann.*, xxxvi. 315; *Handw. der Chem.*, v. 224.

stance resembling liver of sulphur is stated by Chladni in his paper *Ueber der Ursprung der von Pallas gefundenen und anderer ihr ähnlicher Eisenmassen*, page 26, to have been found at Coblence.[1] Wöhler[2] detected the presence of a little free sulphur in the carbonaceous meteorite of Cold Bokkeveldt (1838, October 13th); and Roscoe[3] found 1·24 per cent. of sulphur in the remarkable carbonaceous aerolite which fell at Alais (1806, March 15th).

Galle's paper contains a detailed examination of the observations of the path of this meteor, made over a wide area.

1873, August 24th.—Marysville, California.[4]

All the facts that I have yet been able to gather respecting this fall are that an aerolite, weighing 12lbs., crashed through the tree-tops with a bright flash, and was buried to the unusual depth of eight feet in the ground. When dug out it was so hot that it could not be handled.

Found 1873, August 27th.—Eisenberg, Saxe-Altenburg, Germany.[5]

A block of metal, weighing 1·579 kilog., was left exposed on the surface of the ground at the foot of the Schneckenberg, north of Eisenberg, by a heavy thunder shower washing away the surrounding soil. It is a finely granular iron, through which are disseminated here and there yellow particles of magnetic pyrites or troilite. Unlike metallic masses of undoubted meteoric origin, it contains neither nickel nor cobalt; when etched with nitric acid it exhibits, in place of figures, minute star-like forms. It has the composition:—

Iron	97·27
Phosphorus	0·21
Carbon	0·44
Silicic acid	1·50
Graphite	0·90
	100·32

The presence of silica was confirmed by treating the white amorphous rounded particles, which remained undissolved, with hydrofluoric acid.

1873, September 23rd, 5·10 a.m.—Khairpur, 12 miles south of Multan, 36 miles E.N.E. of Bhawalpur, Punjab, India. [Lat. 29° 56′ N.; Long. 72° 12′ E.][6]

The morning is described as having been remarkably clear, and the sky unclouded, with a faint glow in the east, the sun still being 45 minutes below the horizon, when a meteor, or rather a cluster of meteors, appeared to the west of an observer at Khairpur. Each

1 *Comment. de rebus in Scientia Naturali et Medicina gestis*, xxvi. 179.

2 F. Wöhler. *Sitzber. Wien. Akad. Wiss.*, 1863, February 24th. *Phil. Mag.*, xxv. 319.

3 H. E. Roscoe. *Proc. Lit. Phil. Soc. Manchester*, 1863, February 24th. *Phil. Mag.*, xxv. 319.

4 *Nature*, 1st January, 1874. (From *Iron*.)

5 H. B. Geinitz. *Sitzungs-Ber. der Isis zu Dresden*, 1874, 5.

6 H. B. Medlicott. *Jour. Asiat. Soc. Bengal*, 1874, pt. ii. no. ii. 33. *The Pioneer*, Sept. 30th, 1873.

of them exceeded in brightness a star of the first magnitude, and the breadth of the train left behind them is estimated to have been from 3° to 5°. The first thought of the eye-witness was that he was gazing at a rocket; this, however, was soon dispelled, as the phenomenon, instead of fading out, rapidly increased in brightness, and continued to move towards him, leaving a train behind. According to the report of the Rev. G. Yeates, "its motion was not very rapid but steady, and by the time it had reached about 10° of the meridian, which it passed south of the zenith, it assumed an exceedingly brilliant appearance, the larger fragments, glowing with intense white light with perhaps a shade of green, taking the lead in a cluster, surrounded and followed by a great number of smaller ones, each drawing a train after it, which, blending together, formed a broad belt of a brilliant fiery red." It lit up the whole country, and produced an effect similar to that of the electric light. It proceeded in this way till it reached a point nearly due east, paling again as it drew near the horizon, and at about 20° above it, it appeared to go out rather than to fall. The train, which continued very bright for some time, was distinctly traceable three-quarters of an hour afterwards. At first it changed to a dull red; then, as the morning broke, to a line of silvery-grey clouds that divided into several portions, and floated away on the wind. The track of the meteor was unusually long, extending through nearly 180°. It first appeared near the star Algenib, at the time about 15° above the horizon on the west, passed close under Orion, the lowest star of which (Rigel) was very near the meridian, and disappeared as already stated. After this had taken place, and while the train still attracted attention, there was perfect silence, which was at length broken by a loud report, followed by a long reverberation, that gradually died away like the roll of distant thunder. This interval is estimated to have been four minutes.

At Bhawalpur the explosion was sufficiently violent to shake the houses and slam the doors. At Bhawalgur, 80 miles from Khairpur, the meteor was seen, but no explosion was heard. It was also observed at Jodhpur and Moradabad, and was probably visible within a radius of 300 miles of Khairpur.

A correspondent of *The Pioneer* of the 30th September records his observations made on the Shujabad road, 13 miles south of Multan. He states that the different fragments into which the meteor broke up were distinctly visible, "more than twenty of them, I should say, moving in parallel courses, two or three of the larger ones taking the lead in the centre, and each of them leaving a tail of red light behind," which blended together, forming one huge band of light. The report, which was very terrific, followed after the lapse of about three minutes and a half, which would make the point where the disruption of the aerolite took place about 42 or 45 miles distant. The train remained very bright for some time, and the clouds into which it was transformed were visible upwards of an hour afterwards, till they faded away in the bright sunlight.

Another correspondent, "Shikaree," states that on the left bank of the Chenab, some 60 miles S.W. of Bhawalpur, the meteor displayed great brilliancy, and that a double detonation followed after an interval of six or seven minutes.

One of the meteorites fell close to a man who had gone out into the jungle for the purpose of nature, and frightened him so much that he hardly knew what occurred, and was under the impression that the stone pursued him for two hours. He showed the spot where it fell, however, and this was the first fragment unearthed and forwarded by the Tuhsildar of Khairpur to Major Minchin, Political Agent for Bhawalpur.

The stones fell partly in the State of Bhawalpur and partly in the Multan district, on either bank of the Sutlej, over an area extending 16 miles in a direction bearing 35° S. of E., with a breadth of about three miles. The largest and perhaps the greater number fell to the eastward of Khairpur, and penetrated the earth to the depth of about 1½ feet. They are preserved in the following collections in India, and weigh respectively :—

	Lbs.	Oz.	Grs.
Lahore Museum	10	12	126
Indian Museum	9	11	219
" "	7	14	236
Geological Museum... ...	1	2	412
" "	0	3	79

Of those stones or fragments that fell on the Multan side seven have been heard of: four at different spots near Gogewala well, E.S.E. of Mahomed Moorut; two at Khurampur, on the right bank of the Sutlej; and one at Araoli, two miles N.W. of Khurampur. Of these one only is in known hands, that from Mylsi Pergunnah, which weighs 6 oz. 70 grs.

The account of the physical characters of the stones is very meagre. They are all very irregular in form, and are more or less broken. While some of the fractures have evidently been accomplished by hand, and others probably took place at the moment of falling, several appear to have occurred during the fall, as the glazed surface has been partially renewed. The stones are of the usual steel-grey colour, and exhibit compact crypto-crystalline texture. One specimen has the specific gravity = 3·66.

1873, December.—Coomassie, Kingdom of Ashantee, Africa.[1]

In a letter from the War Correspondent of *The Standard* it is stated that among the portents of evil which were observed at Coomassie while the British Army halted on the banks of the Prah, an aerolite fell in the market-place of Coomassie. In reply to an application for further details respecting this event, Mr. Henty writes that he obtained his information from one of the clergymen of the Basle Mission. He says: "They mentioned these 'prodigies' as matters of common rumour and belief at Coomassie, but they do not appear to have even made any inquiries whatever as to their truth. Coomassie was deserted when we got there, so there was no opportunity of gaining further information."

[1] G. A. Henty. *March to Coomassie.* London: Tinsley Bros. 1874, page 320.

1874, May 20th.—Virba, near Vidin, Turkey.[1]

This meteorite fell with a loud noise, and entered the ground to the depth of one metre; it weighed 3·60 kilog. A fragment presented to the Paris Collection by His Excellency Safvet Pacha is covered with the usual dull black crust: a fractured surface shows the meteorite to have a light-grey colour and a very finely grained texture, with grains of metal distributed through the mass; in certain parts spherular structure is apparent. In a microscopic section it was found that the transparent and almost entirely colourless stony particles act on polarized light.

The metallic portion is nickel-iron, the presence of an iron sulphide is recognized by the action of acid, and numerous small black grains of chromite are distributed throughout the stone. A part of the siliceous constituents gelatinize with acid, indicating the presence of olivine; and a residue, which resists the action and constitutes less than one-half of the weight of the stone, is believed to be enstatite.

The Virba stone belongs to the large class of which the meteorite of Lucé, Sarthe, France (1768, September 13th), may be taken as the type; and is most closely allied to the aerolites of Bachmut, Island of Oesel, St. Denis Westrem, Buschof, Dolgaja Wolja, and those of other localities mentioned in Daubrée's paper.

1874, August 1st, 11 p.m.—Hexham, Northumberland.[2]

In *The English Mechanic* is a letter from a person signing himself "Ralph Lowdon," of Gateshead, stating that at the above time and place "a massive ball of intense light," accompanied by other pear-shaped balls of fire, was seen to drop towards the earth. The aerolite, which is alleged to have fallen in an orchard on the bank of the North Tyne, at no great distance from Hexham, is stated to have been found the following day at 9 A.M. at a depth of 14 inches in the soil, still quite warm, and to have weighed 301½lbs. Letters directed to the above are returned by the Post-office authorities, while a courteous reply which I received from the Rev. H. C. Barker, of Hexham, states that the editor of *The English Mechanic* must have been misinformed. The rev. gentleman writes: "To make assurance doubly sure, I have made inquiry in several quarters, and cannot find even the slightest foundation for the statement."

1875, February 12th, 10·30 p.m.—West Liberty, Iowa.[3]

An account of a very sensational kind is given in the *Dubuque Times* of a brilliant meteor which was seen at Iowa City and other points of Central Iowa at this date. Its course was from S.E. towards N.W. It had apparently about half the diameter of the moon, and was accompanied by a beautiful train; it was seen to separate

[1] G. A. Daubrée. *Compt. rend.*, lxxix. 276.
[2] *The English Mechanic*, August 21st, 1874.
[3] *The Engineer*, March 26th, 1875, 217. *Amer. Jour. Sc.*, ix. 407. *Compt. rend.*, lxxx. 1175.

into several fragments, and after an interval of about three minutes three explosions were distinctly heard. One of the fragments of the meteorite fell about three miles south of the village of West Liberty in an open field, sinking, so it is stated, 15 feet into the ground. Of the 100 kilog. which have been found, the greater portion is in the Iowa State University Museum; 25 kilog. have been sent to Paris. Daubrée traces a resemblance between this stone and the aerolites of Vouillé and Aumale.

1875, April—.—Zsadány, Hungary.[1]

A preliminary note on this fall of meteorites has been communicated to the Natural History Society by Krenner, the Keeper of the Minerals in the Hungarian Museum at Pest. Their descent was attended with an explosion, and the peasants who were witnesses of the fall state that the fragments were cold at the moment they reached the ground. Nine fragments, rather smaller than walnuts, were collected, six of which, weighing 144 grammes, are in the possession of the above Society. The investigation of this aerolite has been undertaken by Wartha and Krenner; the former will subject it to analysis, the latter examine its mineralogical characters. It may be mentioned that the stones which fell at Dhurmsala in India[2] (1860, July 14th) are stated to have been so cold that they could not be held in the hand.

186–.—Barratta Station, Deniliquin, Australia.[3]

It is stated in an issue of *The Australasian* of the date given below that Mr. Russell, the Government Inspector at Sydney, while visiting Deniliquin, succeeded in acquiring for the Sydney Museum the greater part of a meteorite which fell "some years ago" at Barratta Station, 35 miles "below Deniliquin." The stone originally weighed 300lbs., but it had been broken up and fragments had been distributed as curiosities. An announcement appeared last year to the effect that Mr. Liversidge, of the University of Sydney, had made a preliminary examination of its composition. No details have apparently yet appeared. (As the date of the fall has not been defined, I insert this imperfect notice at the conclusion of Part I.)

Part II.

In this Part it is proposed to present a digest, similar to that given in Part I., of the memoirs and notices published during the years 1869—1875 in reference to meteorites, which either have been seen to fall or have been found at a date earlier than the beginning of 1869, including a description of their history, or of any investigations of the physical and chemical characters of these meteorites, together with such results as tend to correct earlier analyses.

[1] *Egyetértés és Magyar Ujság*, 23rd April, 1875.

[2] W. von Haidinger. *Sitzber. Akad. Wiss. Wien*, xlii. 305; xliv. 285.

[3] *The Australasian*, April 22nd, 1871.—*Nature*, iv. (1871), 212.—See also *The Journal of Science*, January, 1874, 123.

The Pre-Homeric Meteoric Irons.[1]

Von Haidinger, in April, 1870, in a letter addressed to Fr. von Hauer, directed attention to a communication which he had received from Sir John Herschel, supplementing a short notice on the above subject,[2] which was sent to von Haidinger six years previously by Prof. Miller, of Cambridge.

Herschel points out that the Trojan irons do not constitute the only instance in the writings of Homer where that metal is mentioned in a manner to provoke the assumption that all the iron used at that time by the Greeks was of meteoric origin. The mass of iron which Achilles offered as a prize at the funeral games of Patroclus, and which had been carried off as treasure from the palace of Eetion, is described as *σόλον αὐτοχόωνον* (crude, self-fused); while to show the scarcity of iron in those times, it is stated that this block of metal, though of such a size that a strong man could hurl it some distance, would prove a sufficient supply of iron for five years to the winner, and render unnecessary a journey to the city for the purchase of that metal. Again, among the prizes for the archers we find, in addition to ten two-edged axes and ten hatchets of bronze, *ἰόεντα σίδηρον* as material for arrow-heads. This is not "crude, self-molten" (meteoric?) iron, but forged metal, converted probably on the surface by cementation into steel. It is far from improbable that in early times, before the art of forging iron was known, many metallic masses of meteoric origin lay strewn over the then known surface of our planet, which, as their adaptation to the useful arts became known, were collected and turned to use, as was the case with gold. Von Haidinger further called attention to the statement in Sir John Herschel's letter that the latter had noticed these references to the early use of iron before he perused the former's first report published in 1864. Herschel remarks, moreover, that

[1] W. von Haidinger. *Mitt. Anthrop. Gesell. Wien*, i. no. 3, 63.

[2] W. von Haidinger. *Sitzungsber. Acad. Wiss. Wien*, l. 288.—In this paper, *Ein vorhomerischer Fall von zwei Meteoreisenmassen bei Troja*, Miller called attention to *Iliad*, xv. 19-32:

19. Ἄκμονας ἧκα δύω . . . .
31. . . . . . . μύδρους δ' ἐνὶ Τροίῃ
32. Κάββαλον· ὄφρα πέλοιτο καὶ ἐσσομένοισι πυθέσθαι.

Miller remarking that these lines were enclosed in brackets, and given as doubtful, applied to Babington, who wrote: *Iliad*, xv. 30. Memorat Eustathius post hunc versum nonnullos adscripsisse hos versos.

Πρὶν ὅτε δὴ σ' ἀπέλυσα ποδῶν· μύδρους δ' ἐνὶ Τροίῃ
Κάββαλον· ὄφρα πέλοιτο καὶ ἐσσομένοισι πυθέσθαι·

Adding as a commentary: Καὶ δείκνυνταί, φασιν, ὑπὸ τῶν περιηγητῶν οἱ τοιοῦτοι μύδροι. [" lumps of this kind they say are pointed out by the Perigetae "]. Eustathius was Archbishop of Thessalonica, and died in 1198. Moreover, he says that the Periegetae called them " anvils from above (fallen from heaven)." Von Haidinger points to the incomplete character of the passage without lines 31 and 32:—

Dann dir erst löst' ich die Füsse, die Klumpen aber nach Troja
Warf ich hinab, noch später Geschlechtern die That zu verkünden.

He also alludes to the fact that two iron masses fell at Braunau, Bohemia, and two at Cranbourne, near Melbourne, Australia.

in south-east Africa considerable masses of nickel-iron have been met with,[1] which were collected and worked into implements by the aborigines, when they learned their value by intercourse with Europeans. Further instances where iron is mentioned are to be found in *Iliad*, iv. 485, and *Odyssey*, i. 184.[2] We know of other cases where meteoric iron has been worked into implements; among which may be mentioned the iron of Arva, Szlanicza, Hungary, and that composing the blades of the Esquimaux knives discovered in 1819 by General Sir Edward Sabine,[3] which are in the British Museum Collection of Meteorites. (See also pages 156–7).

1628, April 9th, about 6 p.m.—Chalows and Barking, near Wantage, Berkshire.[4]

Mr. Webb directs attention to a letter, preserved in Wallington's *Historical Notices*, i. 13, which was written in 1628 "by Mr. John Hoskins, dwelling at Wantage, to his son-in-law, Mr. Dawson, a gunsmith, dwelling in the Minories without Aldgate," relating to the fall of meteorites. Describing the explosion, Hoskins says: "It began as followeth :—First, as it were, one piece of ordnance went off alone. Then, after that, a little distance, two more; and then they went as thick as ever I heard a volley of shot in all my life; and after that, as if it were the sound of a drum. . . . . Yet this was not all; but, as it is reported, there fell divers stones, but two is certain in our knowledge. The one fell at Chalows, half a mile off (from Wantage), and the other at Barking, five miles off. Your mother was at the place where one of them fell knee deep, till it came to the very rock, and when it came at the hard rock it broke, and being weighed, all the pieces together, they weighed six-and-twenty pound. The other that was taken up at the other place (Barking) weighed half a tod, 14 pound."

1640, Whit Sunday, about Noon.—Antony, near Plymouth.[5]

Among the tracts and broadsheets which the authors have incorporated in their valuable catalogue of the writings of Cornishmen is one by the Rev. Arthur Bache bearing the title, "The Voyce of the Lord in the Temple; or a most strange and wonderfull Relation of God's great Power, Providence, and Mercy, in sending very strange sounds, fires, and a Fiery Ball into the Church of Anthony, neere Plimmouth, in Cornwall, on Whit Sunday last, 1640. To the scorching and astonishment of fourteen severall persons who were smitten, and likewise to the great Terrour of all the other people then present, being about 200," etc. This little pamphlet is chiefly

[1] O. Buchner. Die Feuermeteore. Giessen: 1859. Page 128.

[2] For the early history of iron see F. X. M. Zippe. Gold, Kupfer, Eisen. *Almanach Akad. Wiss. Wien*, 1856, Anhang. 135.—F. X. M. Zippe. *Geschichte der Metalle.* Vienna, 1857.—E. Buchholz. Die Homerischen Realien. Leipzig: 1871. (chapter on Mineralogy), 289–349.

[3] E. Sabine. *Quart. Jour. Sc.*, vii. 79.

[4] T. W. Webb. *Nature*, July 14th, 1870.

[5] G. C. Boase and W. P. Courtney. *Bibliotheca Cornubiensis.* London: Longmans, 1874.

devoted to harrowing descriptions of "divers hurts" received by the congregation. One man, in recording his experiences, stated that he heard "as it were the hissing of a great shot." It is not improbable that this phenomenon was caused by lightning.

(To be continued in our next Number.)

IV.—On the Occurrence of Boring Mollusca in the Oolitic Rocks.[1]

By Prof. J. Morris, F.G.S.

THE occurrence of perforations due to Lithophagous mollusca has been frequently observed in the Oolitic rocks, viz. in the Inferior and Great Oolite, Cornbrash, Coral-rag, and Portland beds. During a recent visit, with some of the students of the Agricultural College, Cirencester, to a quarry near there, further evidence of a similar fact was obtained. The quarry is situated near the canal on the farm land of Mr. Sargeant, and has been long worked for road stone and building stone, and, according to the Geological Survey, belongs to the Forest Marble division of the Great Oolite series, and exhibits the structure known as "false-bedding or oblique lamination," and occasionally the flagstones in this and other neighbouring quarries show ripple-marks and tracks of marine animals.

In looking for fossils, two or three perforated nodules were observed on the surface of the ground, and seeing that this district is generally free from foreign or transported pebbles, it naturally occurred that they had been exposed and thrown aside and left during the working of the quarry; upon examination of the section then open, the nodules appeared to occupy the position shown in the following section. A portion of the upper surface has been removed, and the following is a general account of the section seen in the quarry in *descending* order:—Rubbly limestone, about four feet; brown shaley clay, with thin calcareous shaley bands, slightly oolitic, full of oysters, *O. Sowerbyi*, of different sizes, more or less broken, and other fossils. At the level of this bed in one part of the quarry were the nodules, round or lenticular in shape, of a fine, compact, highly calcareous and ferruginous claystone, or indurated marl, of light brown colour, both the under, lateral and upper surfaces of which have been perforated by some boring mollusc, as *Lithodomus* or *Gastrochæna*; the holes are pear-shaped, and are found all round the margin of the nodules, and are filled either with a yellowish brown mud with some oolite grains, due to subsequent infiltration, or with crystallized calcite; in some cases the shells of the mollusc have been preserved. Besides the perforations, the surfaces of many of the nodules are covered with attached valves of oysters and a carinated *Serpula*, the interspaces, as well as the valves of the oysters, being incrusted with a delicate species belonging to the *Polyzoa*, probably a *Berenicea* or *Diastopora*; the thickness of this bed is about three feet. The nodules are coated with similar

[1] Abstracted and revised by the author from the Agricultural Students Gazette, April, 1875.

species of *Polyzoa* and of *Serpula*, to those which incrust the separate plates and joints of the *Apiocrinus rotundus*, which occur in the Bradford-clay at Bradford, Wiltshire.[1] Coarse shelly limestones, more or less irregular and false-bedded, with partings of clay full of fossils; among the most common are *Terebratula digona*, *Lima cardiiformis*, *Pecten vagans*, *Modiola imbricata*, *Ostrea Marshii*, *O. Sowerbyi*, *Trigonia*, *Corbula*, *Nucula*, *Arca*, *Serpula*, spines and plates of *Echini* (*Acrosalenia* and *Cidaris*), Corals (*Cladophyllia Babeana*), *Rhynchonella media*, *Cerithium*, *Cylindrites*, *Nucula*, and fragments of wood.

Below is a laminated grey and brown clay with shells, overlying a thick-bedded, hard, grey, fine-grained rock, destitute of fossils, a highly siliceous and calcareous rock, with thin flagstones in the middle; the rock is used for road stone.

Professor Church has kindly examined this stone, which, when perfectly dry, was found to contain 39 per cent. of silica.

The perforated nodules above mentioned evidently show a change of condition from the underlying bed, and probably infer not very deep water, in which a partially hardened mud was broken up into separate pieces which were subsequently perforated by the Lithodomous mollusc. Some movement must have taken place in their position, for it is observed that both the upper and under surfaces are equally bored and the sides also: rarely do the borings interfere with each other, and they are generally of a uniform size about an inch deep; further evidence of comparatively quiet conditions is exhibited not only in the perforations, but in the surfaces of the nodules being frequently more or less covered by the attached valve of oysters and a carinated *Serpula*, as well as incrusted with a species of *Diastopora* or *Berenicea*, showing a period of repose between the underlying and overlying strata, in which the false-bedding is seen.[2] Similar perforated pebbles have been observed in the cutting of the Oolite on the Railway, near Long Handborough, Oxfordshire.

Prof. Phillips, in describing the section of the large old quarry opened on the west side of the Cherwell, at Enslow Bridge, shows that immediately below the strata referred to, the Forest Marble, is a white and partly compact Oolite in three or four beds, the top being ferruginous, often covered by Oysters, and *drilled* by *Lithodomi*.[3]

The Rev. H. Jelly mentions, that "in the superior members of the Great Oolite formation in the neighbourhood of Bath there occur masses, sometimes of considerable size, of *Astreæ*, perforated most

[1] See fig. 338, p. 330, Lyell, Elements of Geology, 1874.

[2] Sir C. Lyell, in alluding to the Crinoidal plates at Bradford, overgrown with *Serpulæ* and *Polyzoa*, says, "Now these *Serpulæ* could only have begun to grow after the death of some of the stone-lilies, parts of whose skeletons had been strewed over the floor of the ocean before the irruption of argillaceous mud. In some instances we find that, after the parasitic *Serpulæ* were full grown, they had been incrusted over with a polyzoan, called *Diastopora diluviana;* and many generations of these molluscoids had succeeded each other in the pure water before they became fossil! (Elements of Geology, 1874, p. 330.)

[3] Geology of Oxford and the Valley of the Thames, 1871.

profusely by several species of *Lithodomi*." The cavities formed in the coral by the *Lithodomi*, and frequently their unoccupied shells, contained one, two, or even as many as three double valves of *Modiola* enveloping one another.[1]

Mr. Hull[2] mentions that, near Burford, the upper rock bed (Great Oolite) is frequently pierced by *Lithodomi*, and affords evidence of having been consolidated contemporaneously with its deposition. Occasionally we find beds of conglomerate, formed by waterworn fragments of the underlying limestone, loosely heaped together, as if they had been broken up by a storm, dashed about, and then retained in their places by the rapid formation of new calcareous matter. Again, on the west side of the valley of the Churn, the upper white limestone is pierced by *Lithodomi*, and contains sandy druses in which *Echini* and other fossils frequently lie concealed; it forms a marked geological horizon, the only one which offers a line of demarcation between the Great Oolite and Forest Marble.

Mr. Lycett thus describes[3] the section of the quarry at Minchinhampton Common, in descending order:—*Planking*, a shelly coarse oolite limestone, 10 feet; soft, thin-bedded, rubbly calcareous oolite, 10 feet; *oven-stone*, soft yellowish oolite, shelly, the testacea being arranged in layers which assume every kind of inclination; *numerous holes, bored by Lithodomi*, pervade it, 6 feet; *weather-stone*, greyish brown oolitic shelly limestone; basement bed, a brown and blue band, 6 feet; argillaceous limestone, full of oysters, 4 inches. Mr. Lycett[4] also observes that "it is a common occurrence to find isolated pebbles of hard calcareous freestone in the shelly beds of the formation; but at the Hyde, one mile from Minchinhampton, a small road-side section discloses conglomerate of the Great Oolite; the rolled calcareous hard pebbles having a matrix of fine-grained limestone."

M. Eugène Deslongchamps[5] describes a section at Lion-sur-Mer (Calvados) as follows:—

Oxford Clay, four metres.

Great Oolite, with many Gasteropods and Lamellibranchs (Langrune beds), upper surface hard and *perforated* (chien superieur),[6] 15 metres.

Marly limestone, full of *Polyzoa*, with *Ter. digona*, *T. cardium* (*Caillasse* of Ranville), six metres.

Ranville building stone, a little oolitic, surface hard and *perforated* (chien inferieur), 15 metres.

Caen limestone, representing the Fullers-earth, surface hard and *perforated*, 20 metres.

[1] Mag. Nat. Hist. 1839, p. 551.

[2] Hull, Geology of Country around Cheltenham, pp. 64, 65; Mem. Geol. Survey, 1857.

[3] Lycett, The Cotteswold Hills, 1857, p. 93.

[4] Lycett, *ibid.* p. 99.

[5] E. Deslongchamps, Notes pour servir à la Géologie du Calvados, Caen, 1863. Bull. de la Soc. Linn. de Normandie, vol. vii.

[6] The workmen of Ranville give the name of *chien* to these hard and perforated surfaces, in allusion to the hardness of these bands. *Dur comme du chien* is a Normandy expression which indicates an extreme degree of compactness.

Marly bed at base, about one metre.

In a quarry at Fresnay-la-Mère is the following section[1]:—

Caen limestone, with *Rhynchonella spinosa*, two metres.

Limestone, hard and a little siliceous, very fossiliferous, upper part with *Pecten corneus*, lower part with *Ammonites Parkinsoni*, *A. Niortensis*, *Ter. sphæroidalis*, *Ter. Phillipsii*, *Ancyloceras annulatus*, upper surface worn and *perforated*, one metre.

Yellowish limestone (sometimes sandy) with *Pholadomya fidicula*, *Ter. perovalis*, upper surface worn and *perforated*, 60 centimetres.

Yellow clay, no fossils, 10 centimetres.

Marly limestone, many fossils, *Pecten æquivalvis*, 20 centimetres.

Yellowish, marly, sandy limestone, *Bel. niger*, *Pecten æquivalvis*, *Rhynchonella tetrahedra*, *Terebratula punctata*, $1\frac{1}{2}$ metres.

Conglomerate more or less sandy, 2 metres.

Yellowish clay, with pebbles, half-metre.

Palæozoic rocks, much eroded.

The Inferior Oolite also presents evidences of lithophagous perforations. Mr. Hull states, that the beds which rest immediately on the Pea-grit are generally sandy and ferruginous. They are frequently pierced by *Lithodomus attenuatus* (Lycett), and are filled with spines and plates of Echini, Corals, and Pentacrinite stems. The beds above these and below the Oolite Marl are considered most valuable as a building material. They present obliquely laminated structure very frequently, remarkable examples of which are exhibited in one of the quarries at the north side of the Cleeve Cloud, and at Frocester Hill.[2]

At Cleeve Cloud the Ragstone (Upper Inferior Oolite) contains a bed of yellow siliceous sand at or near the base, which may also be observed in a quarry near the Tower, at Broadway Hill.

Mr. Lycett mentions that at Scar Hill, near Nailsworth, below the Upper Ragstones there is a bed of compact oolite, bored everywhere by small vertical tubes of marine annelida.[3]

Sir H. de la Beche,[4] in describing the district around Whatley, Nunney and the Vallis Vale, states, "Not only is a large portion of the area, wherein the Inferior Oolite is seen to rest on the Carboniferous limestones, observed to have presented a marked even surface, viewed on the large scale, for the deposit of the former, but, throughout, this surface has been *drilled into holes by lithodomous animals*, which must have existed in the seas at the commencement of the Inferior Oolite. The holes which were observed by Professor John Phillips, in 1829, are of two kinds, one long, slender, and often sinuous, extending several inches into the Carboniferous limestone, the other entering that rock a short distance only. In the former we find no traces of shells, in the latter we often discover them, in the situations in which they lived. In both holes we find the matter of the Inferior Oolite, which entered them from above at the time of its

[1] Deslongchamps, *ibid.* p. 19, pl. 2.
[2] Hull, Memoirs, p. 37. Hull, *ibid.* p. 45.
[3] Lycett, The Cotteswold Hills, p. 49.
[4] Memoirs of the Geological Survey, 1846, vol. i. p. 289.

deposit. In some places the shells of oysters may be observed attached to the surface of the Carboniferous limestone on which the oysters lived, and these are occasionally pierced through by the borers, which found such shells remaining on the rocks after the animals which had constructed them had died, as we now observe on many sea-coasts." Further[1] we "have direct evidence that in some places, after a certain amount of accumulation and a bed had been formed, there was a state of repose, for in the upper part of some beds of the Inferior Oolite, succeeding each other, the surface has been bored by the same lithodomous animals which pierced the surface of the subjacent Carboniferous limestone or Lias conglomerate, as the case may be. The fact is, doubtless, somewhat general in this part of the district, and is valuable, not only as showing the repose between the accumulations constituting the different beds, each in succession being sufficiently consolidated to permit the boring animals to establish themselves on its upper surface, but also as pointing to the probable consolidation of many a bed in other parts of the Oolite series, prior to the deposition of another above it, where this kind of evidence cannot be adduced."

With regard to the false-bedding, one of the characteristic features of the Forest Marble, and one by which it may be contrasted with the beds of the upper zone of the Great Oolite, showing a marked change in the nature of marine conditions, coincident with the introduction of this formation,[2] De la Beche remarks,[3] "The beds known as the Forest Marble frequently exhibit a minor mixture of fine detritus; probably thrown down from mechanical suspension, with broken shells, fish palates, broken pieces of wood, and oolitic grains, sometimes strewed horizontally, but very frequently in a diagonal manner, showing the sweeping of loose materials on the bottom into a minor depression. Sometimes the sandstone is marked by ripple or friction ridges and furrows, and crossed by the tracks of marine animals which had crawled over the surface, one surface beneath the other at short depths, so that we have the markings of sea-bottom over sea-bottom. Such false-bedded accumulations of shells and grains of oolite with drifted pieces of coral, are not uncommon in other parts of the Oolitic series, being observable in the Great Oolite about Bath, in the Inferior Oolite of some localities, and in other parts of the series, which exhibits, as a whole, many minor alterations of sea-bottom, a large proportion of the limestones being composed of the hard parts of marine animals, a character wherein they differ very materially from the Lias limestones."

Brief as the above remarks are, it may be observed that there are many points of geological interest to be studied in the quarries around Cirencester, with regard to the physical and organic conditions under which the various strata were accumulated, the clay-beds due to fine mud thrown down from mechanical suspension, the sands to the drift of heavier detrital matter, and the limestones to the accumulations of shells, oolitic grains and corals (sometimes seen as coral

[1] De la Beche, *ibid.* p. 291. [2] Hull, Memoir, *ibid.* p. 72.
[3] De la Beche, Memoir, *ibid.* p. 285.

reefs), with fragments of drift-wood from some distant land, sometimes bored, or covered with attached valves of oysters. Here, too, the surface features have been variously modified, partly by faults, but mostly by denudation, by which different layers of the oolitic strata have been exposed, so as to modify the nature of the soils according to the character of the rocks from which they have been derived, for there is little evidence of foreign detrital matter (except in one or two cases) being spread over the land or remaining in this neighbourhood.

NOTICES OF MEMOIRS.

I.—Note on the Transition from Carboniferous to Permian.

Communicated by Count A. G. von Marschall, F.C.G.S., etc.[1]

In Spitzbergen the late German Expedition obtained the following fossils from Horn Sound, on the south-west coast:—

1. *Spiriferina Hoeferiana*, sp. n.
2. *Spirifer Wilczeki*, Toula.
3. ,, *striatus*, Martin?
4. ,, *lineatus*, Martin, sp.
5. ,, ———, var. *elliptica*, Sow.?
6. *Camarophoria crumena*, Martin, sp.
7. *Productus Weyprechti*, Toula.
8. ,, sp. (comp. *P. Prattenianus*, Norwood).
9. ,, *undatus*, Defr.?
10. ,, *Wilczeki*, sp. n.
11. ,, *longispinus*, Sow.
12. ,, *Spitzbergianus*, sp. n.
13. ,, (*Strophalosia*) *Cancrini*, M. Vern. and K.
14. *Strophalosia Leplayi*, Gen.
15. *Chonetes Verneuiliana*, Norw. and Pratten; var. nov.
16. ,, *granulifera*, Sow.
17. ,, sp. ind.
18. *Pecten* (*Aviculopecten*) *Wilczeki*, sp. n.

With the exception of one species, the individuals are all of small size. Some are genuine *Carboniferous* species, and some genuine *Permain*; and they appear to be transitional from the Carboniferous limestones to the Zechstein; all occurring in a well-determined group of strata; but some, characteristic elsewhere of one or other of the above-mentioned formations, being found occasionally in the same hand-specimen, as *Productus longspinus* and *Strophalosia Cancrini*. This circumstance may be regarded as corroborative of the gradual passage from the Carboniferous to the Permian, as held by Prof. Geinitz for Nebraska, and by Dr. G. Stache for the southern Alps.

II.—The Geology of the Burnley Coal-field.

This work, which is one of the recently published Memoirs of the Geological Survey of England and Wales, includes a description of the country around Clitheroe, Blackburn, Preston, Chorley, Haslingden, and Todmorden, and explains Quarter-sheets 88 N.W., 89 N.E., and 92 S.W. of the One-inch Geological Map. It is by

[1] From the Proceed. Imp. Acad. Sci. Vienna, June, 1874, vol. lxx. p. 133.

Professor Hull and Messrs. Dakyns, Tiddeman, Ward, Gunn, and De Rance.

The work contains a description of the physical features of the district, a detailed account of the Carboniferous rocks along the Ribble Valley, special accounts of the Burnley and Chorley Coal-fields, with notices of the Permian and Triassic rocks, of the Glacial and Post-Glacial Drifts, Igneous rocks, minerals, etc. There is also an extensive catalogue of the fossils from the Carboniferous rocks, prepared by Mr. Etheridge, and a list of works and papers relating to the geology of Lancashire and some parts of the adjacent country, by Messrs. Whitaker and Tiddeman.

REPORTS AND PROCEEDINGS.

Geological Society of London.—I.—April 14th, 1875.—John Evans, Esq., F.R.S., V.P.R.S., President, in the Chair.—The following communications were read :—

1. "Descriptions of New Corals from the Carboniferous Limestone of Scotland." By James Thomson, Esq., F.G.S.

In this paper the author described some forms of corals from the Carboniferous Limestone of Scotland, which he regards as new species, and as belonging to three new genera allied to *Clisiophyllum.* In the group which he names *Rhodophyllum* the calice is circular and shallow; the epitheca thin and smooth; the septa thin and numerous; and the columellar boss dome-shaped, slightly raised above the inner margin of the primary septa, and clapsed by subconvolute ridges. The species referred to this genus are *Rhodophyllum Craigianum, R. Slimonianum, R. Phillipsianum, R. Argylianum, R. reticulatum,* and *R. ellipticum.* *Aspidiophyllum* has the calice generally circular, shallow; the septa forming thin laminæ for about half their length from within, when they become flexuous, and the columellar boss promient and helmet-shaped. The species are named *A. Koninckianum, A. Huxleyanum, A. cruciforme, A. elegans, A. Hennedii, A. Danai, A. dendrophyllum, A. ellipticum, A. Pagei, A. scoticum,* and *A. laxum.* The third genus, *Kurnatiophyllum,* is most nearly allied to *Rhodophyllum,* but has the columellar space slightly raised above the inner margin of the primary septa, and crowned by bending or wavy lamellæ, some of which pass over the central space in sinuous folds. The species are described under the names of *R. concentricum, clavatum, Tyleranum, intermedium, ellipticum, Ramsayanum, Youngianum, Harknessianum, lamellifolium, bipartitum, octolamellosum, Haimianum, Edwardsianum,* and *Davidsonianum.* In a specimen of *Aspidiophyllum Huxleyanum* the author noticed in the open interseptal space a small tube, 4 lines long, around the inner margin of which there was a group of oval bodies, which, from their close proximity to the inner margin of the primary septa and their form, he is inclined to think may be ova.

2. "On the Probable Existence of a Considerable Fault in the Lias near Rugby, and of a New Outlier of the Oolite." By J. M. Wilson, Esq., M.A., F.G.S.

The author called attention to what appeared to him to be a great fault in the Lower Lias at the village of Low Morton, near Rugby, where a sandpit is worked against the face of a steep hill to a depth of nearly 50 feet. The sand in the valley, as proved by wells and borings, is of great depth. Above the sandpit is a claypit, and the author stated that the clay is bounded towards the sand by a highly inclined face of clay, against which the sand is thrown. This face of clay can be clearly traced for a distance of more than half a mile, running in a S.E. and N.W. direction. If continued to the S.E., it would pass close by Kilsby Tunnel, the difficulties met with in the construction of which may have been due in part to a continuation of the fault; whilst if continued to the N.W., it would coincide generally with the valley of the Clifton Brook, the bed of which is also occupied by a great depth of sand. The line of fault thus passes between Rugby and Brownsover, and the author suggests that it is the cause of the presence on the summit of the Brownsover plateau of an extensive oolitic mass of Stonesfield-slate character. The line of fault continued further would connect with the Atherstone and Nuneaton fault, and agree with this in having its downthrow on the N.E. side.

3. "On a Labyrinthodont from the Coal-measures." By J. M. Wilson, Esq., M.A., F.G.S.

The fossil referred to in this paper was from the Leinster Coal-measures, and was regarded as probably belonging to the genus *Keraterpeton* of Prof. Huxley, although the outer posterior angles of the skull do not appear to have been prolonged into cornua.

4. "On *Cruziana semiplicata.*" By J. L. Tupper, Esq. Communicated by J. M. Wilson, Esq., M.A., F.G.S.

In this paper the author gave a detailed description of a slab of unknown origin, but said to have been obtained from a workman at Bangor, containing several specimens of the fossil described by Salter under the name of *Cruziana semiplicata.* The author discussed the characters presented by the fossil, the mode of crossing of those specimens which crossed each other in the slab, and especially the structure shown where a transverse section of the fossil was to be seen, in which, when perfect, it was clearly of an elongate elliptical form, with a cortical or external layer inclosing a medullary portion of lighter colour. From his examination of the specimen the author seemed inclined to ascribe to *Cruziana* an animal origin, and to regard it rather as fossilized animal structure than as a cast of the track left by the feet of some animal passing over the surface of the sand.

The following letter was read from A. Irving, Esq., F.G.S., dated High School, Nottingham, April 8th, 1875:—

"There is at the present time a very interesting section of Rhætic beds and Boulder-clay exposed in the cutting of a new railway which is in process of construction from Melton Mowbray to Nottingham. The distance of it from the latter place is between five and six miles. In some places extensive erosion has taken place of the Paper Shales of the Rhætic series; in others they are much contorted; in others, again, the material of these shales appears to have been broken up, almost pulverized, and redeposited among the drifted materials. The boulders vary in size from that of a man's fist to two or three times that of a man's head, and are nearly all composed of rounded and subangular masses of Lias limestone; many of them are distinctly striated with the ice-markings so familiar to geologists. Large and small quartzose pebbles are extremely common, derived, in all probability, from the denudation of the Bunter, further north by a very few miles. There is also much rotten Marlstone from the Middle Lias, and a great quantity of re-deposited red Keuper marl. A few large boulders of Carboniferous limestone are contained in the medley mass; and a fragment of Coal-measure Sandstone has also been found containing the most distinct impression of a specimen of *Stigmaria*, with rootlets attached: this is now in the possession of Mr. Parry, the engineer of the line. For some portion of the slope of the hill the Boulder-clay forms the surface of the ground, and it caps the whole of the hill which lies between Plumtre and Stanton-on-the-Wolds, though it is here covered by several feet of drift-marl, free from pebbles and boulders, and evidently derived from the Keuper formation, whose outcrop occupies a large area of the ground in the neighbourhood. At the shaft the Boulder-clay is 70 feet thick. In some places the Paper Shales have been eroded quite through, so that the Boulder-clay rests immediately upon the lower grey marls of the Rhætic, which are very regular, and have the same thickness (10 to 15 feet) here which they have in other sections in this country.

"I have thought it right to send the Society this brief communication, though several months must elapse before the railway will be lowered to its proper level. When this is done, we shall get a section, I hope, second only to that at Westbury-on-Severn."

II.—April 28, 1875—John Evans, Esq., V.P.R.S., President, in the Chair.—The following communications were read:—

1. "On *Stagonolepis Robertsoni*, and on the Evolution of the Crocodilia." By Prof. T. H. Huxley, Sec. R.S., F.G.S.

After referring to his paper read before the Society in 1858, the author stated that he had since obtained, through the Rev. Dr. Gordon of Birnie, and Mr. Grant of Lossiemouth, further materials, which served at once to confirm the opinion then expressed by him, and to complete our knowledge of *Stagonolepis*. The remains hitherto procured consist of the dermal scutes, vertebræ of the cervical, thoracic, lumbar, sacral and caudal regions, ribs, part of the skull and the teeth, the scapula, coracoid and intercavicle, the humerus, and probably the radius, the ilium, ischium and pubis, the femur, and probably the tibia, and two metacarpal or metatarsal bones. The remains procured confirm the determinations given by the author in his former paper, except that the mandible with long curved teeth therein supposititiously referred to *Stagonolepis* proves not to belong to that animal.

From the extant evidence it appears that in outward form *Stagonolepis* resembled one of the existing Caimans of intertropical America, except that it possessed a long narrow skull, like that of a Gavial. The dermal scutes formed a dorsal and ventral armour, but the dorsal shield did not contain more than two, nor the ventral shield more than eight longitudinal series of scutes. The posterior nares were situated far forward, as in Lizards, neither the palatine nor the pterygoid bones uniting to prolong the nasal passage backwards, and give rise to secondary posterior nares, as in existing Crocodiles. The teeth referred to *Stagonolepis* have short, swollen, obtusely pointed crowns, like the back teeth of some existing Crocodiles; they sometimes present signs of wear. The scapula resembles that of recent Crocodiles; the coracoid is short and rounded like that of the Ornithoscelida and of some Lizards, such as *Hatteria.* The humerus is more Lacertian than in existing Crocodiles. The acetabular end of the ischium resembles that of a Lizard, and the rest of the bone is shorter dorso-ventrally and longer antero-posteriorly than in living Crocodiles, thus resembling that of *Belodon.* The latter Reptile, from the Upper Keuper of Württemberg, is the nearest ally of *Stagonolepis*; both are members of the same natural group, and this must be referred to the order Crocodilia, which was described as differing from other Reptilia as follows:—The transverse processes of most cervical and thoracic vertebræ are divided into more or less distinct capitular and tubercular portions, and the proximal ends of the corresponding ribs are correspondingly divided; the dorsal ends of the subvertebral caudal bones are not united; the quadrate bone is fixed to the side of the skull; the pterygoids send forward median processes which separate the palatines and reach the vomer; there is an interclavicle, but no clavicles; the ventral edge of the acetabular portion of the ilium is entire or but slightly excavated; the ischia are not much prolonged backwards, and the pubes are directed forwards and inwards; the femur has no inner trochanter, and the astragalus is not a depressed concavo-convex bone with an ascending process. There are at least two longitudinal rows of dorsal dermal scutes.

The Crocodilia are divided by the author into three sub-orders:—

I. Parasuchia, with no bony plates of the pterygoid or palatine bones to prolong the nasal passages; the Eustachian passages enclosed by bone; the centra of the vertebræ amphicœlian; the coracoid short and rounded; the ala of the ilium high, and its acetabular margin entire; and the ischium short dorso-ventrally and elongated longitudinally, with its acetabular portion resembling that of a Lizard.—Genera: *Stagonolepis, Belodon.*

II. Mesosuchia, with bony plates of the palatine bones prolonging the nasal passages, and giving rise to secondary posterior nares; a middle Eustachian canal included between the basioccipital and basisphenoid, and the lateral canals represented only by grooves; vertebral centra amphicœlian; coracoid elongated; ala of the ilium lower than in the preceding, higher than in the next sub-order, its acetabular margin nearly straight; ischium more elongated dorso-ventrally than in the preceding group, with its acetabular margin deeply notched.—Genera: *Steneosaurus, Pelagosaurus, Teleosaurus, Teleidosaurus, Metriorhynchus* (*Goniopholis*?, *Pholidosaurus*?).

III. Eusuchia, with both pterygoid and palatine bones giving off plates which prolong the nasal passages; vertebral centra mostly procœlous; coracoid elongated; ala of the ilium very low in front, its acetabular margin deeply notched; ischium elongated dorso-ventrally, with its articular margin deeply excavated.—Genera: *Thoracosaurus, Holops,* and recent forms.

The Mesosuchia are intermediate in character between the other two groups; the Parasuchia, where they differ from the Mesosuchia, approach the Ornithoscelida and Lacertilia, especially such as *Hatteria* and *Hyperodapedon,* with amphicœlous vertebral centra. The Eusuchia, on the other hand, are the Crocodilia which depart most widely from the Ornithoscelida and Lacertilia, and are the most Crocodilian of Crocodiles.

After indicating at some length the succession of modifications in the above three groups, the author remarked that if there is any solid ground for the doctrine of evolution, the Eusuchia ought to be developed from the Mesosuchia, and these from the Parasuchia, and showed that geological evidence proved that the three groups made their appearance in order of time, in accordance with this view. Thus in the Trias there are the genera *Belodon* and *Stagonolepis* of the sub-order Parasuchia. In the Upper Lias we have *Steneosaurus,* (*Mystriosaurus*) and *Pelagosaurus,* the first represented also in all Mesozoic formations up to the Kimmeridge Clay; in the Fuller's Earth *Teleosaurus* and *Teleidosaurus* occur; in the Kelloway Rock *Metriorhynchus,* also met with in the Oxford Clay and Kimmeridge Clay; in the Wealden, *Goniopholis, Macrorhynchus, Pholidosaurus,* and unnamed Teleosaurians; and in the Upper Chalk *Hyposaurus*; all belonging to the Mesosuchia. In the Upper Chalk again the Eusuchia make their appearance, represented by the genera *Thoracosaurus, Holops,* and *Gavialis* (?). How far back the Parasuchia extend in time is not known, but they are not found in any formation subsequent to the Upper Trias. The author described a fragment of a skull of a Wealden Crocodile, in which the posterior nares are smaller and situated further back, than in *Metriorhynchus* or *Steneosaurus.*

Of the nearest allies of the Crocodilia, the Lacertilia and Ornithoscelida, the former may be traced back from the present day to the Permian epoch, and the latter from the later Cretaceous to the Triassic epoch. The author discussed the question whether these types exhibit any evidence of a similar form of evolution to that of the Crocodilia. The cranial structure of the Permian Lacertilia is almost unknown, and the only important deviation from the type of the existing Lacertilia in the skeleton is that their vertebræ are amphicœlous, not procœlous. With this exception there is no evidence that the Lacertilian type of structure has undergone any important change from the later Palæozoic times to the present day; and this change seems to have occurred earlier in the Lacertilia than in the Crocodiles, as a sacral vertebra of a Lizard from the Purbecks has the centrum concave in front and convex behind.

With regard to the Ornithoscelida, the author noticed that the researches of American Palæontologists proved the existence of those Reptiles in abundance in quite the latter part of the Cretaceous epoch. He had himself indicated the existence of various forms of Dinosauria in the Trias. He confirmed his former opinion that *Zanclodon* from the Upper Keuper of Württemberg is a Dinosaur, and probably identical with *Teratosaurus* (von Meyer), in which case its affinity to *Megalosaurus* is exceedingly close. He corrected a statement in a former paper with regard to the ilium of the Thecodontosaurians, which he had turned the wrong way, and stated that when regarded in its proper position this ilium is much more Lacertilian than that of *Megalosaurus.* From this and other evidence of detail he inferred that the Triassic Thecodontosauria were devoid of some of the most marked peculiarities of the later Ornithoscelida, while the most ornithic of the latter belong to the second half of the Mesozoic period. The oldest Crocodiles differ less than the recent ones from the Lacertilia, and the oldest Ornithoscelida also approached a less differentiated Lacertian form, the two groups seeming to converge towards the common form of a Lizard with Crocodilian vertebræ. *Cetiosaurus* is also a reptile with a vertebral system like that of the Thecodontosauria and Crocodilia, but with more Lacertilian limbs, and *Stenopelyx* may be in the same case. It may therefore be convenient hereafter to separate the Thecodontosauria, *Cetiosaurus* and perhaps *Stenopelyx* as a group, "Suchospondylia," distinct from both the Ornithoscelida and the Crocodilia (or "Sauroscelida").

Prof. Huxley, in reply to remarks on his paper by Professors Duncan and Seeley, stated that the Indian Crocodile, *Parasuchus*, was very like *Belodon* in the jaw and teeth, the scapula and coracoid, the vertebræ, the ilium, and the tibia. The tibia had the proximal end like that of a Lizard, the distal like that of a Crocodile. The remains from India furnish a new point of resemblance between the Indian deposits and those of Elgin. With regard to the difference in the position of the nostrils, he did not know that any reason could be given for this, unless the modification might facilitate respiration when the animal was engaged, after the manner of Crocodiles, in drowning its prey; but this would not hold good in the case of the Gavial, which feeds on fish. The food of *Stagonolepis* was doubtful: the teeth were often more or less ground down; but whatever the food was, it might be an advantage to the animal to be able to breathe when its mouth was full. In reply to Prof. Seeley, he stated that his comparisons were not founded on the skull alone, but on the other principal characters. Purely morphological considerations would not be sufficient alone, but they must enter into the question. As to the older Lacertilia, he had paid some attention to them, and considered that in all their characters they resembled the existing forms; the modern *Sphenodon* (or *Hatteria*) of New Zealand was exactly like the Triassic species. The skull in *Belodon* most closely resembles that of *Hylerpeton* ?

2. "On the remains of a Fossil Forest in the Coal-measures at Wadsley, near Sheffield." By H. C. Sorby, Esq., F.R.S., F.G.S., Pres. R. M.S.

In this paper the author described the occurrence of a number of stumps of *Sigillariæ* in position and with Stigmarian roots attached to them in the Coal-measure Sandstone in the grounds of the South Yorkshire Lunatic Asylum, and mentioned that the authorities of the Asylum, in order to preserve these remains, had erected two wooden buildings over them. The trees seem to have grown in what is now a bed of earthy clay-like shale; there to have dried and rotted down to the level of the surrounding mud, leaving hollow stumps, to be afterwards filled up with the sand now forming the superjacent bed of sandstone. The stumps exposed were about ten in number, spread over forty or fifty yards of ground. The smaller trunks have four, and the larger ones eight roots; and the author specially called attention to the fact that, from the position of these roots, by analogy with existing trees, we may infer the direction of the prevalent wind at the time the trees were growing, and that it appears to have been from the west.

3. "On *Favistella stellata* and *Favistella calicina*, with Notes on the affinities of *Favistella* and allied genera." By H. Alleyne Nicholson, M.D., D.Sc., F.R.S.E., F.G.S.

The author noticed that *Columnaria alevolata*, Goldf., has been described by Hall under the name of *Favistella stellata*, as pointed out by Milne-Edwards and Haime, and discussed the course to be pursued, another Coral from the Trenton Limestone having been described and figured by Hall and other American palæontologists as *Columnaria alveolata*, Goldf. The distinction between the two forms consists chiefly in the degree of development of the septa, these being marginal and rudimentary in the latter species, and reaching nearly or quite to the centre in the true *C. alveolata*, Goldf. He proposed to refer both to the genus *Columnaria*, accepting *Favistella* as a sub-genus, and retaining Hall's specific name for its type. In case of the identity of *Favistella stellata*, Hall, and *Columnaria alveolata*, Goldf., being definitively established, he suggested the name of *C. Halli* for the species described by Hall as *C. alveolata*. He also described a new species of the genus under the name of *Columnaria* (*Favistella*) *calicina*.

Mr. A. Tylor brought an apparatus for determining the heat evolved by the friction of ice upon ice, with a view to explain an important element in glacier motion. The apparatus, consisting of plates of ice 8 inches square, placed in two wooden chucks 3 inches deep, was enclosed in a double sheet-iron case containing ice and salt, and kept at 32° F. One block of ice was rotated,[1] and the other pressed against it. Four pounds of ice were reduced to water at the rate of $1\frac{1}{4}$ lb. in an hour, in consequence of the motion, that is by the heat evolved by friction of ice upon ice, the pressure being 2 lbs. on the square inch. Ice evaporates at 32°, and the same quantity of ice was reduced, when still, at about the rate of $\frac{1}{4}$ lb. in an hour at 32° F. Air at a higher temperature found its way into the case, and promoted melting. When this experiment was tried in a room at 54° F. with the same apparatus without any

[1] One chuck revolved 500 times in a minute.

outer case, the friction of the ice in motion, at the above pressure, increased the production of water $3\frac{1}{4}$ times above the rate observed when the ice was still and exposed to a temperature of 54° F. The amount of heat evolved was nearly as much as with oak moving upon oak well lubricated, and the coefficient of friction was between 0·1 and 0·2. Glacier motion is impossible without a continual supply of water to lubricate the bottom. No doubt the action of denudation by glaciers produces heat to a small extent. The water obtained by melting the surface of the glacier by the sun's heat in the glacial period could not be sufficient alone. The position of deep lakes in all parts of the world in immediate connexion with mountains and their absence in places away from mountains shows that deep lakes are integral parts of mountains; and, in fact, lakes are deepest exactly where the glaciers, once covering the mountains, were in the best position to act as lake excavators. There can be no doubt that all deep lakes in the world, including those in Central Africa, below the Equator, are purely of glacial origin, and that the cold in the Glacial Period was nearly equally intense in the southern and northern hemispheres, and the Atlantic was not only lower, but great part of it was frozen. Glacial surface-ice would move much faster than the bottom-ice, and the side-ice than the surface-ice, and therefore fractures would be continually occurring through all parts. The water produced by this great friction of ice upon ice would fall through the fissures to the bottom. He had pointed out that a glacier moved twice as fast when it was eight times as thick,[1] and the influence of weight on motion must be considered a most important element. The present temperature of a thin glacier was found by Agassiz, from observation, to be one-third of a degree below freezing; but Mr. Tylor assumed that in such a lake-glacier as he had drawn, and supposed to exist in the glacial period, the temperature might be assumed to be very much below freezing, the greater cold arising from immense evaporation and other causes. He therefore concluded that the water produced by friction of ice upon ice falling to the bottom of the lake-glacier through fissures would rapidly freeze, and then expanding one-tenth, would impel the glacier (shod or armed with blocks of stone and sand at the bottom) up a gradient of 1 in 20, excavating the Swiss and other lakes 30 or 40 miles long, and 1200 feet deep in this manner. Mr. Tylor calculated that with half an inch per annum of mean excavation over the whole lake-bottom, the lake of Zurich could be excavated in 15,000 years. Prof. Ramsay had pointed out, from geological evidence, that such lakes have been excavated by ice, but he did not indicate how this was mechanically possible (see Quarterly Journal, 1862).

Mr. Tylor referred again to his experiment when the pressure was only 2 lbs. on the inch. In a large glacier such as described by Dr. Hooker in the Himalayan range, where the mean gradient of the surface was 40° to 50° and the actual fall was 14,000 feet in five or six miles, Dr. Hooker found great lakes attendant upon the

[1] Following the same law as flowing water.—See Phil. Mag. Sept. 1874.

mountains. Supposing the ice was a mile thick, the pressure would be half a ton on the inch, in the Himalaya at least, and the production of water by friction of ice upon ice enormous. Friction is dependent upon pressure, distance moved, and mass, and independent of velocity of motion. All deep lakes must be referred for origin to the Glacial, and not to the Preglacial period. They are the direct consequences of the elevation of mountains in the Preglacial or preceding period.

Watford Natural History Society and Hertfordshire Field Club.—March 11, 1875.—John Evans, Esq., F.R.S., President, in the Chair.

"On the Cretaceous Rocks of England." By J. Logan Lobley. Esq., F.G.S.[1]

This lecture, an introduction to the Geology of Hertfordshire, commenced with a reference to the great teachings of the work of William Smith and his successors; after which the stratigraphical position of the Cretaceous system, and the vast area of the Earth's surface within the limits of which Cretaceous deposits may be found, were pointed out.

The fan-like extension of the Cretaceous rocks in England, commencing at the Dorsetshire coast, is marked out by the Chalk, which, speaking broadly, indicates the geographical position of the English Cretaceous rocks generally.

Commencing with the Wealden, each of the great divisions of the system were described.

The Chalk, as *the* rock of Hertfordshire, was specially dwelt upon. The calcareous Foraminiferal and the siliceous Polycistinal deposits on the bed of the Atlantic canal were explained by the aid of diagrams.

The recent researches of the "Challenger" expedition had revealed the previously unsuspected occurrence of a red argillaceous mud at the bottom of a submarine valley of great depth, and as this was probably the residuum of Foraminiferal tests, the calcareous matter of which had been prevented by some solvent process from reaching these lowest depths, the hypothesis of the organic origin of clays, recently enunciated by Prof. Huxley, had been suggested. The local geology and the geological features of the Thames Valley having been described, the dependence of the plants of a district on its geology, as shown by the presence of the fine beeches for which the neighbourhood of Watford is famed, exemplifies the connexion subsisting between the various natural sciences, the study of which this Society is intended to promote.

To Geology, however, and to the study of the Cretaceous rocks of their own county, the members were specially urged to give their attention, since wider views and greatly extended knowledge would surely follow.

The lecture was illustrated by diagrams, maps, and fossils, and under the microscope recent, as well as fossil (Chalk) Foraminifera, etc., were exhibited.

[1] The first communication to the Society.

CORRESPONDENCE.

DENUDATION OF THE WEALD.

Sir,—Mr. Kinahan in his book "Valleys, and their Relation to Fissures, Fractures, and Faults." robs me of the doctrines of Rain and Rivers, and gives them to Messrs. Foster and Topley. I write to beg space to protest against this. Page 195, he says, "We will specially refer to Messrs. Foster and Topley's paper on it (the denudation of the Weald), as these observers have carefully examined the geology of the country," and he quotes the title of their admirable paper "On the Superficial Deposits of the Valley of the Medway with Remarks on the Denudation of the Weald (Quarterly Journal of the Geological Society of London, November, 1865, p. 443)." Page 460 of Messrs. Foster and Topley's paper commences thus: "Part II. On the Denudation of the Weald. Having now described the chief phenomena connected with the superficial beds of the Medway valley, we will pass on to consider the light which they throw upon the much-disputed question of the 'Denudation of the Weald.' We think it will be conclusively shown that 'rain and rivers' have been the main agents in producing the present form of the ground." In the ten remaining pages of Part II., my name on "rain and rivers" is mentioned ten times. And the paper ends as it began. "Conclusion. In conclusion we will revert to the main points discussed in the paper. After describing the gravel of the Medway valley, we have endeavoured to prove that an old river gravel of the Medway occurs 300 feet above its present valley. We have then shown that if this fact be admitted, it follows that so large a denudation has been effected by 'rain and rivers,' that there can be but little difficulty in supposing the present form of the ground in the Weald to have been produced entirely by these agents."

I shall be satisfied, Sir, if you will allow me space for this protest. But I send the following in case it may be thought suitable to your pages:—

Page 200, Mr. Kinahan says, "If the Weald valley was solely due to subærial (so spelt) denudation, there ought to be deposits of chalk flints over the whole area, and not only on the newer beds." The flints are gone where they ought to have gone, and where by the laws of nature they must go—into the rivers. And they have been carried by the rivers to the sea-shore, or towards the sea-shore. At page 47, "Rain and Rivers," I have traced them northward, southward, eastward, and westward. But since then, Mr. Mylne has published his beautiful geological map of "London and its Environs." Mr. Kinahan may see there terraces of flint from 10 to 100 feet above the present level of the Thames. Besides Kensington and Hyde Park, the entire of ancient London, St. Paul's, the Mansion House, and the Bank, stand on these vast accumulations of *river* flint. But the bed and the sides of the valley at London should be London-clay. The flints have been brought by the river. And from whence? Part from the Weald Hill, through the gorges of the Wey and Mole; part from the gorge through the Chiltern Hills which flood Oxford and the soft Oolitic valleys. But for the sea-shore, let Mr. Kinahan examine Romney Marsh, the Delta of the Rother, formed by the wash down of the very highest part of the Weald Hill, Crowborough Beacon, 800 feet high. At Hythe, Dungeness, and Pevensey, he will find the flints with which he would require "the whole area" of the Weald to be covered. But from the top of Crowborough Beacon, the centre of the Weald, how many hundred feet of Hastings sand, Weald clay, Greensands, Gault, Chalk marl and flintless Lower Chalk have been washed away by rain and rivers since the last speck of upper flint-bearing chalk vanished? The flints which remain "on the newer beds" of the Weald (except those from the more recent denudation of the face of the chalk slope) have been *caught* on the low flat soft valleys of the Weald clay behind the hard gorges of the Greensand, and in the soft valleys of the Gault behind the hard gorges of the Chalk. When the beds of these gorges were lowered, the sides of the alluviums, no longer overflowed, were denuded, and the alluviums cut back into terraces. But their flat tops remain till the terraces are entirely cleared away. The formation of these terraces has been always going on at heights decreasing directly as the lowering of the beds of the gorges and valleys. That it is going on now may be seen from the deposit of new alluviums with drift gravel at the levels of the present overflows of the rivers. The same thing may be seen on the *opposite side* of the Greensand hard gorge below Farnham, where the Wey runs *into* instead of *out of* the Weald, and deposits vast quantities of drift gravel and alluvium in the soft valley of the Gault. This, also, is going on now. Rivers are the roads which gravels travel to the sea, though they may be arrested for thousands, nay millions, of years in passing alluviums. Witness the terraces of the Fraser River, etc., which are only gigantic effects of what caused the Medway terraces. That is, throughout the wide wide world, atmospheric disintegration and the erosion of rain form a flat valley in the soft strata behind each harder stratum. Every flood is then checked at the gorge of the hard stratum, and overflows and deposits on the soft flat. When the bed of the hard gorge is lowered, the bed in the soft valley behind is also lowered, and the flooded river, instead of overflowing, cuts back its alluvium, which remains as two terraces. Messrs. Foster and Topley mistake in supposing (pp. 470, 471) that a rise of the land is necessary for the deepening of the river-bed. It would only be necessary for those parts of rivers whose beds are at the level of the sea.

George Greenwood, Colonel.

Brookwood Park, Alresford.

SUBMERGED FORESTS.

Sir,—Submerged forests and the facts connected with them are important, as offering indications of the latest geological changes. Colonel Greenwood's theory, to which he recalls attention in your last Number, is an attempt to account for them without any sinking of the land or rising of the sea. He thinks that the formation of a bar of shingle across the mouth of an estuary would admit of the surface behind it being dry, although it should be below high-water mark; and that a forest might grow there. One sees marsh land in such positions, but unless there are instances of trees of the same kind as those found in submerged forests now growing below high-water mark, it seems doubtful if they grew there formerly. But the important question is, what have been the relative movements of land and sea since these forests were green? Can we correlate changes of level indicated by other phenomena with such as must have raised or depressed these forest lands. Mr. Godwin-Austen, in his paper "On the Superficial Accumulations of the Coasts of the English Channel, and the Changes they indicate,"[1] arrives at the conclusion, from marks impressed upon the hard rocky margins of the Devon and Cornish coast, that there has been "a change of level, which, so far as elevation is concerned, is necessarily the most recent which has taken place on this section (Dartmouth), and which we may estimate at eight to ten feet." A depression of that amount, he remarks, "would convert the valley of the Exe into a salt-water estuary, and account for the beds of *Mactra, Tellina*" (*quæ Scrobicularia*) and *Cardium* found at Alphington." And he states that this movement has been a uniform one throughout, and extends over the area of the German Ocean. Now the remarkable thing is that we have, in every case that I have seen, evidence of such a depression wherever a submerged forest exists. The stumps of the trees are always enveloped in, or covered by, a mud, full of dead shells of *Scrobicularia piperata, Cardium*, and other estuarine shells; generally of large size. This deposit is laid bare by the erosion of the waves at the present day, *pari passu* with the uncovering of the forest itself, as the beach is thrust forward over the marshes. This clay, under the name of "Buttery clay," with its usual shells, extends over a great part of the fen land of this neighbourhood, where they spread it over the peaty soil to give it consistency. Beneath it are the remains of forest trees of large size, which sometimes, as the soil sinks through the effect of drainage, protrude above the surface, so that they require to be dragged out by horse power; otherwise they obstruct the plough. There is a detailed account of a submerged forest at Porlock Bay, by Mr. Godwin-Austen, in which the points usually connected with these deposits are excellently brought out.[2]

Colonel Greenwood's theory will not explain the, I believe universal, presence of the *Scrobicularia* clay covering the old fossils; while this answers exactly to the depression since balanced by the 8–10 foot elevation established on other grounds by Mr. Godwin-Austen. That elevation has brought the forests with their estuarine envelopes to the level of present half-tide. But they *have been* eight or ten feet lower than they are now, and consequently fully "submerged." It seems to me, then, that they are justly entitled to their old appellation, and that it is a mistake to suppose that they

[1] Journ. Geol. Soc. vol. vii. p. 118. [2] Journ. Geol. Soc. vol. xxii. p. 1.

occur without any sinking of the land or rising of the sea. And I, for one, agree with Mr. Kinahan, that they are "submerged" at the present day, in so far that they are below the level suitable to the growth of trees, of the kinds of which they consisted. A singular fact about these old forests that requires explanation is their almost universal occurrence at a certain uniform level of flat land. It might otherwise have been expected, under these circumstances, that they would have grown upon a surface of silt, deposited by water action. But, as far as my observation goes, they usually grew upon the clay, which forms the bed rock of the locality. At Selsey it is distinctly weathered.[1] How came these tracts of uniform level to exist at so many localities?

At some places, however, there is a gravelly bed beneath the forest, and, in such, at Barnstaple occur flint knives.

There is a submarine forest at a much lower level indicated in Mr. Godwin-Austen's paper first referred to (section no. 1, pl. vi.), which must, I think, belong to a period antecedent to that of the forests of which I have been speaking.

I would take the liberty of referring upon the above and kindred topics to my paper on "The Warp," in the Journal of the Geological Society, vol. xxii. p. 553. O. FISHER.

HARLTON RECTORY, CAMBRIDGE.

A VOICE FROM THE PAST.

SIR,—I suppose there has been no more thorough and accurate observer of geological phenomena than the late Prof. Sedgwick. On going through his papers of nigh half a century ago, on the English Lake District, I am constantly struck with his minuteness of investigation, and his careful and logical deductions. Had he been blessed with a good ordnance map, there would have been comparatively little general work left for the Geological Survey to accomplish. The following extract from one of the late Professor's letters, dated May 24th, 1842, is interesting in the present day, when land-ice is supposed by some to have been equal to any task:—"No one will, I trust, be so bold as to affirm that an uninterrupted glacier could ever have extended from Shap Fells to the coast of Holderness, and borne along the blocks of granite through the whole distance, without any help from the floating power of water. The supposition involves difficulties tenfold greater than are implied in the phenomenon it pretends to account for. The glaciers descending through the valleys of the higher Alps have an enormous transporting power: but there is no such power in a great sheet of ice expanded over a country without mountains, and at a nearly dead level."

The various Arctic voyages made of late years have shown that the drifting of pack-ice is more often due to winds of constant direction acting upon the many slight irregularities of the ice, than to currents affecting great thicknesses of the watery strata below.

[1] See the writer's paper on Bracklesham Bed, Journ. Geol. Soc. vol. xviii. p. 74, note.

Perhaps this has scarcely been taken into sufficient account by those who have considered the transportation of boulders by floating-ice. If there really was a considerable mid-glacial submergence—of which I cannot but think there is ample evidence both in Cumbria and in Wales—is it not quite possible that westerly winds prevailed at certain seasons, which might drift large quantities of boulder-bearing ice from the Shap district without the aid of permanent ocean-currents? The difficulties involved in the theories of Messrs. Croll, Belt, Goodchild, and others of the same extreme school, certainly press upon me—and I think I may say also upon others of my colleagues—increasingly, as the country becomes more and more familiar in its features. It is indeed a most startling thought, as one stands upon the eastern borders of the Lake-mountains, to fancy the ice from the Scotch hills stalking boldly across the Solway, marching steadily up the Eden Valley, and persuading some of the ice from Shap to join it on an excursion over Stainmoor, and bring its boulders with it.

The outlying northern parts of the Lake-district, and the flat country beyond, have indeed been ravaged in many a raid by our Scotch neighbours, but it is a question whether, in glacial times, the Cumbrian mountains and Pennine chain had not strength in their protruding icy arms to keep at a distance the ice proceeding from the district of the southern uplands, the mountains of which are not *superior* in elevation. Let us hope that the careful geological observations which will doubtless be made in the forthcoming *scientific* Arctic Expedition will throw much new light on our past glacial period. J. CLIFTON WARD.

KESWICK, *April* 26*th*, 1875.

THE MECHANISM OF STROMBOLI.[1]

SIR,—It is quite immaterial to the validity of the mechanism of Stromboli which I have suggested (Proc. Roy. Soc. 1874) whether the bottom of the crater be 300 to 400 feet, or be 2,000 feet above the sea-level, as no physicist reading the above paper can fail to see.

WESTMINSTER, 19 *May*, 1875. ROBT. MALLET.

SPHENONCHUS HAMATUS, A RHÆTIC FOSSIL.

SIR,—I beg to record my discovery a few days since of a large *Sphenonchus*, in the bone-bed of Aust Cliff, a genus hitherto unknown in the Rhætic formation. I have compared it with a specimen of *S. hamatus* in the Bristol Museum, obtained from the Blue Lias at Keynsham, (an unrecorded find, by-the-bye), and fail to find any points of difference, except that of size; the Rhætic specimen being about half as large again as the other, which agrees well with the Lyme Regis type figured by Agassiz. RALPH TATE.

92, CITY ROAD, BRISTOL, *May* 19th, 1875.

[1] See Mr. Poulett Scrope's critical examination of Mr. Mallet's paper in the GEOL. MAG. for 1874, New Series, Decade II. Vol. I. pp. 529-542. See also Mr. J. W. Judd's article on Stromboli, GEOL. MAG. 1875, Dec. II. Vol. II. No. V. for May, p. 210.

RED ROCKS OF TYRONE AND DERRY COUNTIES.

Sir,—From Mr. Ketley's paper on the coals under the "Red Rocks" of South Staffordshire, we learn that the Coal-measures under certain circumstances may be made up of red strata, and that it is erroneous to class all such red rocks as Permian or New Red Sandstones.

In the Counties Tyrone and Derry there are some of these doubtful aged rocks. The highest of them under the Chalk, called "Redfre," seem to lie unconformably on the others, and probably to belong to the New Red Sandstone. The older ones were in part classified by the late General Portlock as Old Red Sandstone, and in part as Carboniferous, but now the general belief seems to be that they belong to the Permian. During a brief examination of the country made some time since, I found in places among the Coal-measure rocks (which I supposed to be the equivalent of the lower Scotch Coal-measures, such as occur in the neighbourhood of Edinburgh) considerable tracts of these red strata, which led me to suspect that most, if not all, these red rocks of the Counties Tyrone and Derry are portions of the associated Carboniferous rocks. Time, however, did not allow me to investigate the country minutely. In favour of their being Permian, there are fossils said to belong to the Permian type, that have been found in at least one locality; but are not these so-called Permian fossils very like stunted and ill-favoured forms of the Carboniferous fossils, and like what we might expect to meet in those portions of the Carboniferous sea, where the water was impregnated with iron or some other substance adverse to the growth and proper development of animal life? G. H. Kinahan.

THE VOLCANIC DUST OF BARBADOES, 1812.

Sir,—When reading the interesting paper by Dr. Flight on the "History of Meteorites"[1] in the April Number of the Geological Magazine (p. 159), I found a reference to the composition of the Volcanic Dust which fell on the Island of Barbadoes during the great eruption of the volcano of Le Souffrier, in St. Vincent, in 1812, described by Humboldt, and more recently by Lyell,[2] Daubeny,[3] and Scrope.[4] Having just received some of this dust, placed in my hands for microscopical examination,—which had been collected by a relative of mine[5] at that time resident in Barbadoes,—I have thought it may be worth while to note the results.

It may be as well to premise, that this eruption was preceded by the great earthquake of Caraccas in Venezuela,[6] which commenced on the 26th March of the same year, and was felt all along the valley of the Mississippi and the West Indian Islands. The eruption of Le Souffrier took place about a month afterwards, namely, on 27th April, opening by a grand discharge of ashes, which commenced to

[1] Dr. Flight's articles on Meteorites commenced in Geol. Mag., Jan., 1875.
[2] "Principles of Geology," vol. ii. [3] Daubeny, Volcanos, 2nd edit. p. 469.
[4] Scrope on Volcanos, p. 432. [5] The late Mrs. C. T. Cooke, of Cheltenham.
[6] See Geol. Mag. 1871, Vol. VIII. p. 348.

fall on the night preceding the 1st May on Barbadoes, rendering the sky dark at noonday, and finally, after three days continuance, covering all the surface of the country with a hideous pall of dark brown ashes, which it took many a day to remove.

I well remember hearing my deceased relative describe the horror and consternation which pervaded the household and district on that fatal May Day, which realized to the mind one of the plagues of Egypt. The dust appears to the naked eye as an exceedingly fine impalpable powder, of a rich brown colour; with an ordinary pocket-lens the grains are distinctly visible.

The distance from the volcano to Barbadoes is exactly 100 English miles, and, as Daubeny observes, it is remarkable that the ashes were carried to Barbadoes notwithstanding the east wind which was blowing at the time, proving the existence of an upper and counter atmospheric current. As the volcanic mountain rises 4,740 ft. above the sea, the dust may have been blown to a height of 8,000 to 10,000 ft., and thus come within the influence of an upper current of air.

With an objective power of fifty-five diameters, the dust is seen to consist of angular, or subangular grains of a translucent reticulated mineral amongst which are dispersed black particles, sometimes angular, and a very few others of a rounded form and bronze colour. On examining the translucent grains with the polariscope, and under several different magnifying powers, it became evident they consist of felspar. The structure is reticulated and in a very few cases banded; but owing to the irregularity of the forms of the grains, I was unable to determine to which class of the felspars they are referable. My impression is that they are the dust of sanidine, and of a small proportion of plagioclase; such, in fact, as would result from the pounding up of trachyte. The black grains are those of magnetite, and on placing a small magnet near the dust, a movement is immediately observed amongst the grains, which increases in intensity as the magnet approaches contact.

It would be interesting to determine chemically whether or not titanic acid is present, but I fear the grains are too minute for such a determination. The bronze-coloured grains are probably pyrites; they are opaque, but slightly translucent around the margin. I did not observe any other mineral substance. EDWARD HULL.

GEOLOGICAL SURVEY OF IRELAND, DUBLIN.

MISCELLANEOUS.—ROYAL SOCIETY OF EDINBURGH.—On the 5th April, the ninth ordinary meeting of the present session of the Royal Society was held in the Royal Institution—Professor Kelland, Vice-President, in the Chair. Professor Geikie addressed the Society, explaining at length the grounds on which the Council had awarded the Neill prize for the triennial period 1871–74, to Mr. Charles William Peach for his contributions to Scottish Zoology and Geology, and for his recent contributions to fossil Botany. Mr. Peach, the Professor said, had materially increased our acquaintance with the marine fauna of the British seas; he had made known the nest-building habits of fishes and mollusca, and had made important contributions to fossil botany and palæontology. Professor Kelland, in presenting the medal, said that Mr. Peach had cultivated science disinterestedly and in the face of nature, and not from books at second-hand.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. II.

No. VII.—JULY, 1875.

ORIGINAL ARTICLES.

I.—Notes on the Volcanic Eruptions in Iceland.

By G. Poulett Scrope, F.R.S., F.G.S., etc., etc.

ICELAND—that land of Frost and Fire, an island which, though as large as Ireland, is, apparently, but a crust of hardened lava over a seething cauldron of the same substance, bearing on its frozen surface eternal snows and glaciers—has been this year in extraordinary commotion, socially and politically, as well as physically. It has celebrated the millenary of its colonization, and for the first time in this long period received a visit from its sovereign; while it has been so devastated of late by frequent fiery eruptions, the ashes from which destroy its pasturage—the only resource of the islanders—as to have driven them, it is said, to the desperate resolve to emigrate *en masse*, and leave their native land for a safer, at least, if not a more genial residence, in the far North-West of the American Continent.

Within the last month intelligence has arrived of eruptions of a more than ordinary violence having occurred in the high snowy district to the north of Vatnajökull.

The following extract from the *Scotsman*, under date of May 21st, is "from an occasional correspondent" of that paper:

"The volcanic disturbances in the north of Iceland (mentioned in the *Scotsman* in April) still continued when the last mail from that part of the island reached Reykjavik. There seems to be a line of volcanic activity all the way from Vatnajökull to Skjalfandafloi, a distance of about 100 miles. Volcanic outbursts on this line have been frequent during the last four years. They have, however, been confined to the south end of the line in Vatnajökull till the present year. During the first three months of this year the volcanic outbursts have continually been moving northwards, but always continuing in the same line. They are just now traversing the sandy deserts lying between the inhabited district Mijvatns sveit on the west and the river Jökulsá on the east.

On the 12th of March, the spot where one of these outbursts occurred was visited by some of the inhabitants of Mijvatns sveit. This spot is close to the outburst mentioned in the *Scotsman*, just about a mile further to the north. There were fifteen different craters close to each other, and during forty-eight hours they had thrown up a wall, or ridge, of lava about sixty feet high, and further covered the ground round about them with heaps of lava, thus forming a lava tract about five miles long, and half a mile broad.

Another visit was made to the volcanic line on the 4th of April. The locality visited on this occasion was south-east of a hill called Búrfell, and a short distance west of the river Jökulsá. Here three large craters were found, and on the west side of them a large rift had been formed and the ground sunk about 18 feet. The craters were here, as at the other place, in a straight line from north to south, the northernmost being the largest. This crater had an oblong form. Its mouth, or the opening from which the fire issued, reached the enormous length of 600 yards.

From different parts of this wide opening *columns of liquid fire were continually rising to the height of* 300 *feet.* Sometimes as many as thirty such columns rose together at a short distance from each other. The outbursts were intermittent. At one time many columns suddenly rose at the same time, then subsided, and after a few minutes rose again. Inside the enormous cauldron there seems to be a lake of liquid fire, which the steam throws up to the height mentioned. The columns seem quite solid until they have reached their greatest height, then the tops spread out and scatter a rain of molten lava all round. The volcano seemed to act on the same principle as the hot springs, with this difference, that the volcano sent forth *columns of liquid fire, or molten lava,* instead of hot water, and the columns rose to a far greater height than that of the hot springs. That it was steam which sent the liquid fire into the air is further proved by the fact that the outbursts were accompanied by a tremendous roar, as if hundreds of steam-boilers were acting together, and continual reports were heard in the crater when the steam bubbles were bursting. This eruption was accompanied by no smoke, or discharge of ashes, but a semi-transparent steam-cloud rested over the whole.

As this eruption has to this time been confined to the uninhabited parts, and has not discharged any ashes, it has not done any damage; but should the outbursts follow up the same line much further to the north, both the Mijvatns sveit and the districts further north will be in the greatest danger.

On the 29th of March an outburst took place somewhere in the interior, most probably near the sources of the Jökulsâ, and a large quantity of ashes, to the depth of three inches, fell in the east of Iceland, in the districts on both sides of the river, or rather lake, called Lagarfljót, and in the middle of the day the whole neighbourhood was enveloped in total darkness. The ashes from this outbreak were carried as far as Norway. This eruption, although further away from the inhabited parts, has caused much more damage than the other ones, because the pastures have been destroyed in the districts where the ashes fell, and the sheep have to be driven away to other districts.

According to the last accounts from the north, all the volcanic vents which have been opened this year seemed to be in full activity. The glare of the fire was seen in districts more than a hundred miles distant from the actual seat of the volcanos, and even in the south some slight shocks of earthquake are felt. The weather still continues uncommonly mild and fine, and by some this is attributed to the volcanic fires."

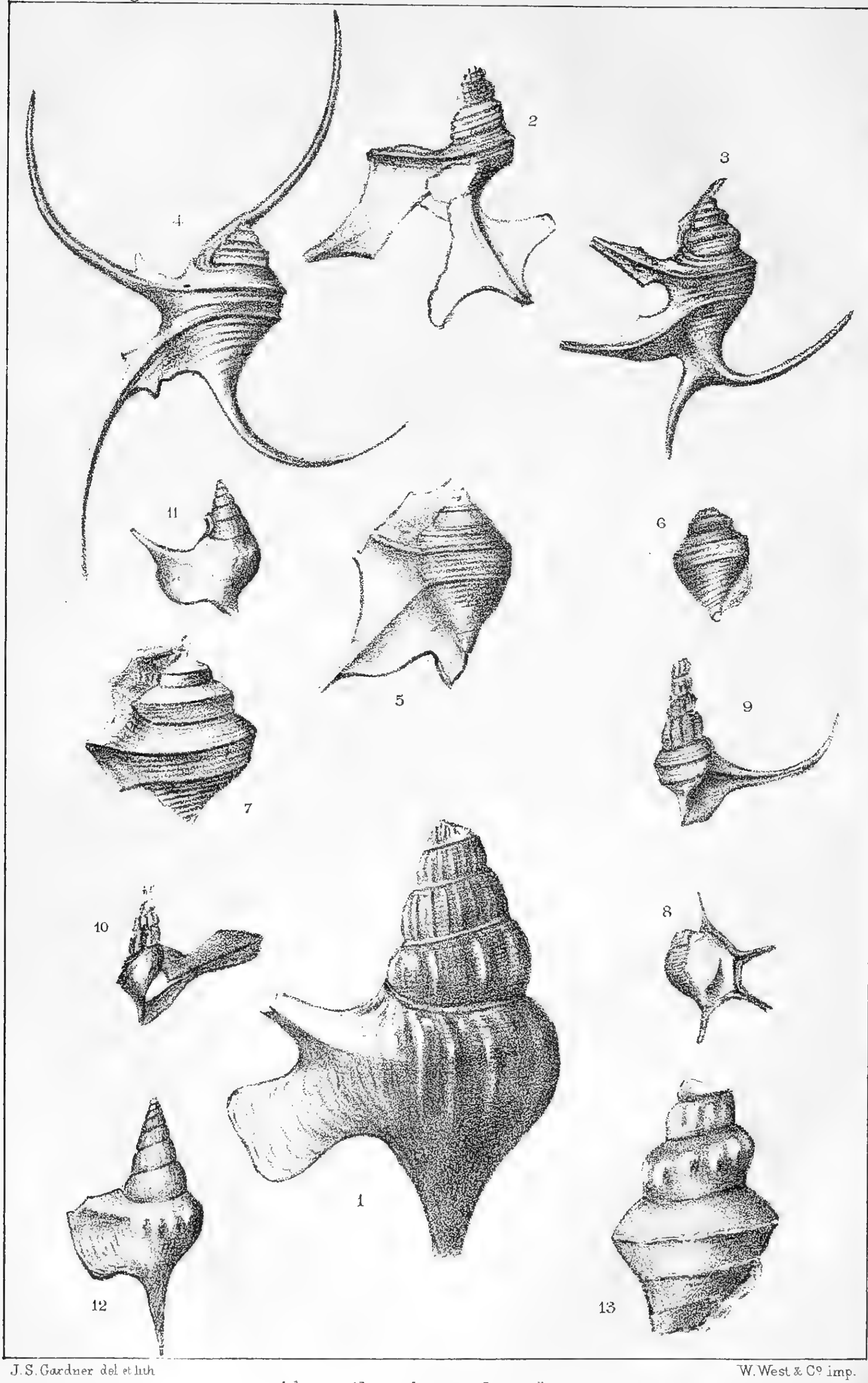
This statement does not appear to emanate from any scientific authority; and in some respects it is not quite clear. The main features of the phenomena described, and the most remarkable, are:

1. The arrangement of the points of eruption in lines stretching from south to north, on one of which no less than fifteen different craters (cones) were thrown up close to each other.

2. On a continuation of the same line the further production of three large crater-cones, one of them having an oblong form, marking a trench or rent no less than 600 yards in length, filled with liquid fiery lava which was thrown up in columns of liquid fire, from successive points, to the height of 300 feet; as many as thirty such columns rising together at a short distance from each other at the same time.

Such an eruption must have given rise, not so much to separate regular cones of scoriæ, as to a continuous ridge-shaped hill, of which examples not unfrequently occur in volcanic districts.

3. This eruption, which is said to have been in activity on the 4th April, discharged *no ashes*; while on the 29th March another outburst, more to the east, produced clouds of ash which not only covered the east of the island, but were carried as far as Norway and Sweden. This latter fact is confirmed by Prof. Kjerulf, of Christiania, who examined the dust, and found it to consist of finely



J. S. Gardner del et lith W. West & Co. imp.

Fossil Aporrhaïdæ.

comminuted pumice, proving the lava, from the trituration of which it proceeded, to have been a highly siliceous trachyte. The apparent absence of ash-clouds from the first-named eruptions may perhaps be attributed to the winds prevailing at the time having driven them in the direction contrary to the observer's line of sight, since it is difficult to suppose that continuous explosions of fragmentary lava, at first liquid, but soon of course consolidated in that cold climate, should not, by the repeated hurtling together and trituration of their substances in the air, as they rose and fell successively, have produced considerable clouds of ash, that is, of comminuted lava or pumice.

We shall look with some interest to the further and more detailed accounts of these Icelandic eruptions, which may be expected to arrive before long; especially as several English explorers, and particularly Mr. Watts, who last year penetrated the Vatnajökull, which no one, it is supposed, not even a native Icelander, had ever trodden, are at present re-exploring the same interesting district.

II.—On the Gault *Aporrhaïdæ*.

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

(PLATE VII.).

(*Continued from page* 203.)

Group 4 (*continued*).—Aporrhaïs Parkinsoni, var. *Cunningtoni*, Gardner. Pl. VII. Fig. 1.

Shell elongated, spire composed of many convex whorls, which are very finely striated, 2 or 3 of the striæ being very distinct and wide apart in front of the sutures. The last 2 whorls have 10 or 11 and the other whorls have 14 or 16 well-marked ribs, with occasional varices. On the last whorl there is a slight angularity in place of keel. The wing exactly resembles that of *A. Parkinsoni*, and in this may be distinguished from that of *A. Mantelli*. The anterior canal is moderately long.

The form here described is intermediate in character between *A. Parkinsoni* and *A. Mantelli*, differing in the number and development of the ribs from the former and in the shape of the wing from the latter. The specimen was obtained by Mr. Cunnington from the Upper Greensand at Devizes, and is now in the British Museum.

The next species described cannot be placed satisfactorily with any of the groups just indicated. From the species being founded on an unique shell, it is just possible that it may be an abnormal variety.

Aporrhaïs macrostoma, Sowerby. Pl. VII. Fig. 2.

Description.—Shell elongated, spire composed probably of 7 or 8 convex whorls. Each whorl has two principal keels, which are prolonged on the last into ridge-like supports to the wing. The first whorl remaining on the specimen now described (probably the 3rd or 4th from the apex) is strongly ribbed transversely, and the two carinæ are very salient; the next whorl has only traces of the ribbing left in the form of widely separated tuberculations on the carinæ. On this and the penultimate whorl a subordinate keel appears between the two principal ones; the body-whorl is ornamented in addition by spiral striæ arranged 1 above, 3 between, and 6 below the carinæ —a sutural keel also becomes visible.

The wing, which is exceedingly expanded, is supported by 3 strong ridges or spines, 2 of the spines being prolongations of the carinæ mentioned above, and the third taking the place of the anterior canal. There were also two intermediate spines rising from the margin of the wing and dying away before reaching the body of the shell, only one of these remains on the figured specimen. The wing had thus five points. The middle spine is unfortunately broken away, but there is no doubt that it was present on the shell. The anterior spine or canal is curved backward, and there is a curious and unusual triangulariform expansion to the left of the canal.

After careful examination under the microscope, the slightest trace only (and I am most doubtful whether it really is a trace) of attachment of the wing to the spire is apparent, and I am now inclined to think that the wing expansion did not extend up the spire, but that its upper termination shown in the figure is the actual posterior margin of the pterygoid process.

History.—Sowerby figured this shell in the Geol. Trans., 2nd series, vol. iv. pl. xviii. fig 23. No second specimen I believe has been found. The fossil figured by Briart and Cornet as this species in no way resembles it.

Locality.—Blackdown.

I am indebted to the courtesy of Mr. E. B. Tawney for the opportunity of examining this unique shell, as well as the original specimen of *A. retusa*, figured by Sowerby on the same plate. I may here state that this latter is identical with the Folkestone and Lyme Regis shells.

Since writing these notes on Aporrhaïdæ, I have had an opportunity of examining the Neocomian forms, descriptions of which, together with those of a few species formerly unknown to me, will be found in the following supplement.

Supplement.

Group 1 (see p. 52). Pl. VII. Fig. 3.

Aporrhaïs Moreausiana, D'Orb.

Description.—Shell thinner and more elongated than that of *A. Fittoni*, and less delicate than *A. retusa*, the spire being composed of 5 or 6 whorls, ribbed spirally and forming a slightly convex angle.

As in most species of this group, the last whorl only is seen to be bicarinated, the anterior keel being hidden by the suture in the remainder. The whorls composing the spire are very angular, much more so than in *A. Fittoni.* On the last whorl there are at least 2, generally 3 spiral striæ between the keels, 3 striæ above the posterior keel, and 4 or 5 below the anterior keel. The two keels are not very prominent, and are somewhat rounded, the posterior one predominates, and is slightly tuberculated. The keels are continued into long curved digitations, the digitations being accompanied for a short distance by expansions of the shell, and being less angular and acute than those of *A. retusa*. There is a short posterior canal accompanying and attached to the spire, but I am not fully acquainted with the length and development it attains. The anterior canal is bifurcated near its commencement, and is then abruptly recurved to the left. There is a well-marked sinus between this canal and the anterior digit—another deep round notch between the two digits of the wing. The wing has altogether an angular appearance. This shell is readily distinguished from *A. Fittoni*, with which it is sometimes found associated, by the more elongated and angulated spire, and the number of ribs on the last whorl.

History.—There is very little doubt that this is the *Pt. Moreausiana* of D'Orbigny, Terr. Crét. vol. ii. p. 301, pl. 211. It is the *Pt. retusa* of Fitton, Quart. Journ. Geol. Soc. vol. iii. from the "Cracker rocks," and it is probably identical with the shell described by Pictet and Campiche in the Terr. Crét. de Ste.-Croix, p. 579, as *Pt. bicarinata*, Sowerby. These learned authors noticed the tendency of the posterior carina to predominate, and their figure 7, pl. xci., shows the bifurcation of the anterior canal. The figure of *Pt. macrostoma*, pl. ii. fig. 3, of Briart and Cornet's Meule-de-Bracquegnies may also have been drawn from a fossil of this species. It is the *Pt. retusa* from Atherfield, of Mantell, Forbes, Morris and other British authors.

Distribution.—Atherfield (Brit. Museum and Geol. Soc. Museum), and Peasemarsh, near Guildford (in Mr. Meyer's collection). It is not possible for me at present to define its continental range.

Aporrhaïs Fittoni, Forbes. Pl. VII. Fig. 4.

Description.—Shell rather thick, shaped very like the preceding, the spire being composed of five spirally striated whorls. The penultimate whorl has three keels and several striæ visible, which disappear on the upper part of the spire, or, more correctly speaking, are reduced to the same prominence only as the striæ; the upper whorls are inflated and ornamented with five or six equal spiral lines, which are decussated by lines of growth. On the body-whorl the carinæ and striæ are much coarser, more prominent, and more rounded than in the last described species. Above the posterior keel there are two faint striæ; between the keels is a single pronounced riblet; below the anterior keel, are three strongly-marked striæ, and beneath these are one or two more faintly marked lines. The two carinæ are more or less, but sometimes very strongly tuberculated, and are continued into strong linear curved digits; there is also a long and elegant posterior canal attached to and extending far beyond the spire; it is recurved gracefully to the left. There is an expansion of the shell on the upper side of the posterior digit accompanying it for a short distance, and terminating abruptly in an angle—a similar expansion occurs on each side of the anterior digit. The anterior canal is long and recurved, and has not been observed ever to become bifurcated. The sinus is well marked.

History.—Described by Forbes as a *Pteroceras* in 1845 in the Quart. Journ. of the Geol. Soc. vol. i. p. 351, pl. iv. fig. 6; referred to by Fitton in vol. iii. as occurring in bed 5*a* of the "Cracker nodules;" and figured by Mantell in the Geology of the Isle of Wight, 1847, as *Pt. retusa.* The references to *Pt. retusa* from Atherfield, in other works, should be read as *A. Moreausiana.* The original specimen figured by Forbes is in the Museum of the Geological Society, it is remarkable for the great prominence of the tubercles on the carinæ.

Distribution.—Atherfield; not hitherto noticed on the Continent.

Apporhaïs histochila,[1] Gardner. Pl. VII. Figs. 5 and 6.

Description.—Shell apparently thinner than that of the last species, but having the same general form. It is bicarinated and finely striated, the front part of the shell is larger than that of *A. Moreausiana,* and has more and seemingly better defined striæ. The spire is depressed, with rounded whorls. The striæ are arranged three or four on the region above the posterior keel, four between the keels, eight or nine anterior to them. The keels are prolonged into digitations, which sustain or strengthen a broad expanded wing, continued to the apex of the spire; of these digits the more anterior is very straight and projected downward, the second is curved upward. Some of the striæ above the posterior keel of the body-whorl are continued on the wing, and follow the curves of the adjacent digit. There is, probably, a posterior canal of the same size, and recurved in the same manner as in *A. Moreausiana.* The anterior canal is not very distinct on the specimen figured, but it seems accompanied by a continuation of the expanded wing to near its end. There is the characteristic sinus between the anterior canal and the front digit, the margin of the wing being otherwise entire.

This shell is very like *A. Moreausiana,* but the shape of the wing with its entire margin, the rounded instead of angular whorls of the spire, and the downward and straight anterior digit, combine to give it a distinct aspect. The body-whorl is larger in proportion than it is in the two species just described, and this character might seem to identify the numerous casts that are found in the Upper Greensand and Gault. It will be, at all events, safe to consider casts resembling this shell, and found on the same horizon, to belong to this species, instead of to *A. Fittoni* or *A. Moreausiana,* which characterize the Lower Greensand. It is distinguished, in common with the two last, from *A. retusa* by its elongated form, the less relative prominence of the anterior keel, and the number of striæ. The casts from Cambridge agree with this in form and in the number of striæ below the keels.

History.—This species has been variously labelled in different museums—*retusa, Fittoni,* etc. A good specimen in the Geological Society's Museum is labelled *Pt. Rochatiana,* D'Orb., by H. de la Bèche, but a reference to D'Orbigny's Prodrome suffices to show that this is an error.

Distribution.—Found in the Upper Greensand of Devizes, Lyme

[1] From ἱστὸς webbed, and χεῖλος a lip.

Regis, and Cambridge, and in the Gault of Folkestone; it would therefore appear to have a wide range.

APORRHAÏS GLOBULATA, Seeley.

This shell is described at length by Professor H. G. Seeley in the Annals and Magazine of Natural History for April, 1861. It occurs in the Upper Greensand of Cambridge and Ashwell, and resembles those previously described in most particulars, but is of smaller size.

APPORHAÏS OLIGOCHILA,[1] Gardner. Pl. VII. Fig. 7.

Description.—Shell broad and ovate; spire short and obtuse, with five very angulated whorls, the last being equal in depth to the other five. All the whorls possess two strongly-developed keels; though the anterior keel is hidden by the suture on all but the last whorl, on which both keels are particularly distinct. The whorls are finely striated spirally; on the body-whorl there are six striæ above the keels, three between them, whilst anteriorly it is strongly striated to the canal. The carinæ are extended into digits, which support an expanded lip, continued and attached to the spire up to the apex. The canal and digits of the specimens examined are short, and the outline of the lip is angular. It is a much larger shell than any of those described as belonging to this group.

History.—As stated in the March Number of this MAGAZINE, page 124, there is a specimen of this shell named *R. Mailleana* in the D'Orbigny collection at the Jardin des Plantes. This must, however, be an error, as neither the description nor figure in the Terrains Crétacés resemble it.

Locality.—Grey Chalk of Lyddenspout, between Folkestone and Dover.

APPORRHAÏS PACHYSOMA,[2] Gardner. Pl. VII. Fig. 8.

A small ovate shell, composed of three or four inflated whorls and an expanded wing. The body-whorl is very large in proportion to the whole shell, is rounded, and without carinæ. The spire is depressed, and the whorls inflated and keel-less. The body-whorl has about fifteen striæ, which seem to be finely tuberculated. The columellar lip appears to have been very much incrusted. The aperture is crescentic, and the outer lip is developed into two short canaliculated spines, and is terminated anteriorly and posteriorly by rather short and slightly recurved canals, the posterior one being attached only to the body-whorl. In the young state the shell would resemble a globose form of *Acteon*. It differs from all other Aporrhaïdæ.

Locality.—Grey Chalk of Lyddenspout, where it is rare.

Group 4.—APORRHAÏS ROBINALDINA, D'Orb. Pl. VII. Figs. 11 and 12.

Description.—Shell elongated, conical, spire composed of about eight rather inflated whorls, terminating apically in an obtuse point. The apex under an inch-power microscope is seen to be flattened, the flat region being composed of three inflated, turbinated whorls.

[1] From ὀλιγος little, χεῖλος a lip. [2] From πάχος thick, σῶμα.

The fourth, which is the first descending the spire, is seen to be slightly ribbed; as the whorls increase in size, the ribs, which are narrow and slightly flexuous, become more pronounced, reaching their maximum prominence on the penultimate whorl, where they are 17 or 18 in number; this number is, however, variable, and the ribs are often irregularly distributed; on the last whorl they become shortened and tubercular as they approach the outer lip, and form a ridge on the wing; this whorl is slightly angular or carinated, and generally carries an indication of a second anterior keel. All the whorls are faintly striated spirally, except near the suture, where two or three striæ are strongly marked. The outer lip, in adults, is produced into an expanded wing, prolonged posteriorly into an oblique point; the outer margin is nearly straight, and anteriorly there is a slight sinus. The wing is attached to the penultimate whorl. The aperture is narrow and the canal elongated.

History.—This shell is generally known as *R. Robinaldina* of D'Orbigny, described (1843) in the Pal. Fr. Terr. Crét. vol. ii. p. 282, pl. 206, f. 4 and 5. Pictet and Campiche separate the British species from that of D'Orbigny, which has, according to their views, a shorter and thicker spire, whose length does not equal half that of the whole shell, a less number of ribs, and these shorter on the last whorl. They appear in doubt, however, as they add, "ce groupe est difficile et renferme encore plusieurs espèces inédites ou mal connues." Not having hitherto had an opportunity of comparing actual specimens, I am not in a position to decide the question, and reserve comment for a future occasion; but it is not unlikely, if the forms are really distinct, that they both occur in England, some casts in the Geol. Soc. Museum, from Shanklin and Pulborough, possessing all the characters indicated by Pictet and Campiche. *A. acuta*, P. and C., and *R. Alpina*, are closely allied forms. *A. simplex*, D'Orb., belongs to the Chalk Marl and Gault. Among English authors, J. Sowerby first described it as *A. Parkinsoni*; Forbes, in 1845, vol. i. Quart. Journ., recognized its similarity with *R. Robinaldina*, D'Orb.; Fitton in the Quart. Journ. vol. iii. gives it an extended range, Lower Perna Beds to top of Cracker Group, bed No. 9; and Mantell, in the Geology of the Isle of Wight, 1847, figured this shell under the last adopted name. It has frequently been included in lists of fossils since, and Mr. R. Tate described it in the paper several times previously referred to.

Distribution.—Abundant in the Lower Greensand of Atherfield, Peasemarsh, etc. Pictet and Campiche name it as occurring in the Lower Aptien of Ste.-Croix, Perte-du-Rhône, and Vassy. They have named it *A. Forbesii.*

Aporrhaïs glabra, Forbes.

The following description is partly taken from Forbes's paper in the Quart. Journ. of the Geol. Soc. for 1845, p. 350, pl. iv. f. 5.

Whorls of spire convex and finely striated spirally, the striæ near the suture being so deep as to give them a marginated aspect, and crossed by oblong slender ribs, which are not very numerous. The body-whorl is gently rounded and nearly smooth, or with a few spiral striæ only, near the suture. The penultimate whorl is also free from transverse ribs. The lip is very large and expanded, produced above into a long linear spur. In front the lip has two other diverging spurs of a lanceolate form. The canal is long, and very slender. Length 2½, breadth 1½ inches.

The specimen described by Edward Forbes is from the Atherfield Clay, and the spire has quite perished, but the form of the wing is still perfectly distinct. Other specimens, in the Geol. Soc. Museum, from the Cracker rocks, are very distinct, and show very delicate striæ all over the upper whorls. Fitton in the Quart. Journ. vol. iii. gives it an extended range at Atherfield in the Cracker group, viz. beds 5 and *5a*, 6 and 9.

APORRHAÏS DUPINIANA, D'Orb. Pl. VII. Fig. 13.

Description.—Shell elongated, composed of angulated whorls; the angles or keels of each are situated considerably posterior to the middle of the whorl, and are ornamented by a row of large and strongly marked tubercles on the convexity. On the last whorl there is a salient keel, together with two others less pronounced, anterior to it; these three keels appear to preserve faint traces of the tubercles. The pterygoid expansion of the outer lip is not preserved in the only specimen I have examined, but Pictet and Campiche describe it thus,—"The wing is large; the principal carina is prolonged in a recurved point: there is a sort of webbing or 'palmure' between this point and the spire, the wing forming an expansion attached to the first whorls. In front of the keels the two other ribs form digitations but little marked, and which we only imperfectly know. The mouth is narrow and very incrusted, its lip being thickened. All the shell is covered with longitudinal striæ, of which one is alternately larger than the other." The shell seems strongly to have resembled *A. pes-pelicani,* especially in the attachment and thickening of the lip.

History.—Named *R. Dupiniana* by D'Orbigny in the Pal. Fr. Terr. Crét. vol. ii. p. 281, pl. 206, f. 1-3, and *Chenopus Dupiniana* in the Prodrome. After being mentioned by various authors, it was redescribed and figured by Pictet and Campiche in the Terr. Crét. de Ste.-Croix, p. 589, pl. xcii. f. 1-3.

Distribution.—Found in the Lower Greensand of Sandown, and in both the Aptien and Neocomian beds of France and Switzerland.

EXPLANATION OF PLATE VII.

FIG. 1.—*Aporrhaïs Parkinsoni*, var. *Cunningtoni*, Gardner. From a specimen lately purchased from Mr. Cunnington, by the British Museum, Devizes.

FIG. 2.—*A. Macrostoma*, Sowerby. From the original specimen, now in the Bristol Museum, Blackdown.

FIG. 3.—*A. Moreausiana*, D'Orb. Atherfield.

FIG. 4.—*A. Fittoni*, Forbes. This and the preceding are in the Brit. Museum.

FIG. 5.—*A. histochila*, Gardner. Drawn from a specimen in the Geol. Museum, Jermyn Street. From Devizes.

FIG. 6.—*A. histochila*, Gardner. From a cast, Cambridge.

FIG. 7.—*A. oligochila*, Gardner. From a specimen in author's cabinet. Grey Chalk.

Fig. 8.—*A. pachysoma*, Gardner. From a specimen in author's cabinet. Grey Chalk.
Fig. 9.— } For description see next Number.
Fig. 10.— }
Fig. 11.—*A. Robinaldina* (?), D'Orb. From a specimen in the author's cabinet. Atherfield.
Fig. 12.—*A. Robinaldina* (?), D'Orb. From an unusually developed specimen in the Geol. Museum, Jermyn Street.
Fig. 13.—*A. Dupiniana*, D'Orb. From a specimen in the Geol. Museum, Jermyn Street. Sandown.

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

III.—Contributions to the Study of Volcanos.[1]

By J. W. Judd, F.G.S.

The Ponza Islands.

If the line passing through those three grand centres of volcanic action—Vultur, Vesuvius, and Epomeo—be produced to the westward, it will strike the very interesting igneous masses of the Ponza Islands. These insignificant islands, which, from the early Roman times down to the present day, have figured in history only as places of banishment for criminals, possess for the geologist the very highest interest. This is due not only to the wonderful characters of the rock-masses which compose them, but also to the admirable manner in which these are exposed to our study by the extreme denudation to which they have been subjected.

In 1785 Sir William Hamilton visited these islands, and, being greatly struck by the remarkable features which they present, not only gave a short account of them in the "Philosophical Transactions," but wrote to Dolomieu, calling his attention to the importance of making a fuller examination of them. The illustrious French philosopher spent some time in them during the following year, and as the result of his studies his "Mémoire sur les Iles Ponces" was published in 1788. In the year 1822 Mr. Poulett Scrope made that careful survey of the whole of the islands, which enabled him to lay before the Geological Society in 1827 his well-known memoir upon them,[2] in which so many points of the highest interest in connexion with the characters of the igneous rocks are for the first time discussed. Lastly, in those very valuable investigations concerning the microscopic structure of rocks and minerals, which laid the foundation of a new and important branch of geological science, Mr. Sorby in 1858 largely employed the very remarkable rocks of Ponza, which the researches of Dolomieu and Scrope had shown to present such interesting characters.

After the detailed description of the Ponza Islands, accompanied by elaborate maps and sections, contained in Mr. Scrope's paper, the accuracy of which I have had the opportunity of verifying, anything like a general memoir upon them would at the present time be quite unnecessary. There are, however, certain features presented by the rock-masses of Ponza which appear to throw important light upon some of the at present "open questions" of geology. These it may be desirable to call attention to in the present sketch.

[1] Continued from page 257.

[2] Geol. Trans. ser. ii. vol. ii.

The Ponza Islands, which lie off the entrance to the Gulf of Gaeta, form two small groups of islets and rocks, which are evidently the highest points of submerged tracts of considerable size—for round the islands the depth of water increases very gradually, and the 200-fathom line is only reached at distances of about three miles from the shores; yet the part of the Mediterranean immediately around them affords soundings up to 700 fathoms or more, as in the case of the Lipari Islands.

About thirty miles west of Ischia rise the islands of Ventotiene and San Stefano. These are evidently two fragments, which have escaped denudation, of a great volcano composed of materials precisely similar in character to those forming the island of Ischia—namely, ordinary trachytes with the agglomerates and tuffs derived from them. The foundations of both the islands consist of masses of rock of great hardness and solidity, evidently, as shown by their highly scoriaceous upper surfaces, portions of vast lava-streams; and these are covered by thick masses of more or less stratified tuffs and agglomerates. Ventotiene is one mile and a half long, by half a mile broad, and it rises to a height of 470 feet above the sea-level. The form assumed by this island, on account of the inclined position of its masses of lava and tuffs, is familiar to all geologists from the sketch given in Mr. Scrope's "Volcanos," page 209. San Stefano is similar in character, but of smaller size, being less than half a mile in diameter, and rising to a height of only 272 feet above the sea; its form is illustrated in the accompanying sketch, Fig. 17. By an elevation of 200 fathoms the sea-bottom around these two islands would be converted into an island of conical form, having a diameter of six miles, and a height of nearly 1700 feet.

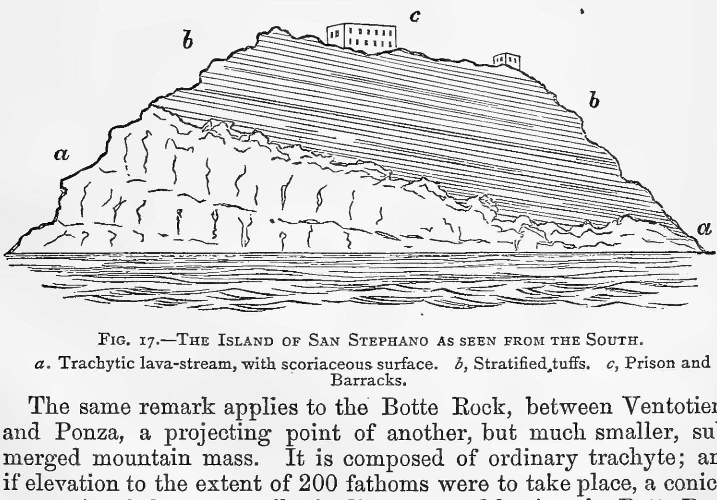


FIG. 17.—THE ISLAND OF SAN STEPHANO AS SEEN FROM THE SOUTH.
a. Trachytic lava-stream, with scoriaceous surface. *b*, Stratified tuffs. *c*, Prison and Barracks.

The same remark applies to the Botte Rock, between Ventotiene and Ponza, a projecting point of another, but much smaller, submerged mountain mass. It is composed of ordinary trachyte; and if elevation to the extent of 200 fathoms were to take place, a conical mountain of about two miles in diameter, and having the Botte Rock as its apex, would be exposed to view.

Twenty miles W.N.W. of the first of these old submerged volcanic cones is situated the other and principal group of the Ponza Islands, consisting of Ponza, Palmarola, and Zannone, with many smaller islets and rocks. The highest part of this group of islands, which are evidently the more prominent points of another submerged tract, is the mountain mass forming the southern part of the island of Ponza, and known as the Monte della Guardia, which rises to the height of 951 feet. This consists of a bulky bed of ordinary trachytic lava, resting upon stratified tuffs, both precisely similar in character to those of Ventotiene and Ischia. The form assumed by this mass of lavas and tuffs clearly indicates that it is the sole remaining fragment of another volcano, composed of the same materials as those to the eastward. (See Fig. 18.)

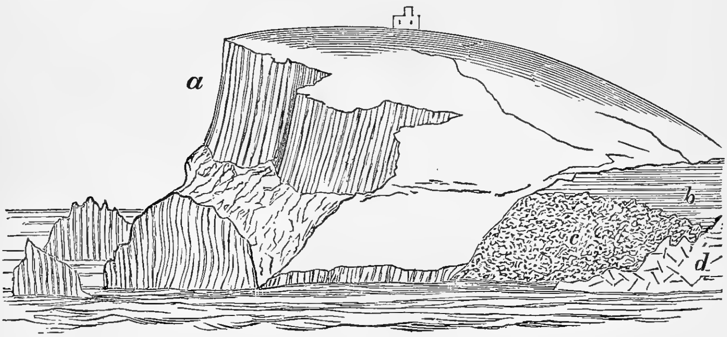


FIG. 18.—THE HEADLAND MONTE DELLA GUARDIA IN PONZA.
a, Columnar trachyte. *b*, Stratified tuffs. *c*, Pumiceous agglomerates. *d*, Intrusive masses of Quartz-trachyte.

In the case of the island of Ponza, however, this relic of an old volcano is seen to rest unconformably upon a still older series of rocks, which constitutes by far the larger portion of the entire group of the Ponzas. These rocks, although evidently of igneous origin, like those which rest upon them, nevertheless offer, alike in their chemical and mineralogical constitution and in their geological relations, a most remarkable contrast to the latter. While the overlying, and evidently newer, rocks are composed of ordinary sanidine-trachytes, with interbedded stratified tuffs, clearly the result of volcanic action at the surface, the latter are made up of highly siliceous pumiceous agglomerates, through the midst of which dyke-like masses of a rock of the same composition as granite, and approaching that rock in many of its characters, has been forced. (See Fig. 19.)

The remarkable features assumed by these older rocks of Ponza, as the result of the mechanical strains to which they have been subjected during their consolidation and crystallization, powerfully arrested, as we have seen, the attention of those pioneers in the study of Vulcanology, Hamilton, Dolomieu, and Scrope; and these rocks are still worthy of the most diligent and attentive study, both as regards their physical relations and their minute structure, by all who desire to investigate the nature, mode of action, and products of volcanic forces.

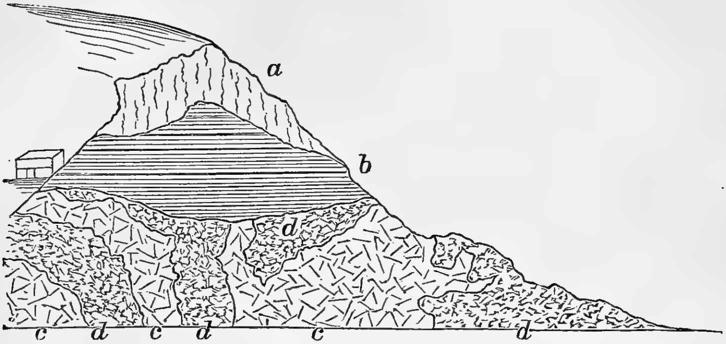


FIG. 19.—WESTERN SPUR OF MONTE DELLA GUARDIA, AS SEEN FROM THE NORTH SIDE OF LUNA BAY.

a, Trachytic lava. *b*, Stratified tuffs. *c*, Intrusive masses of quartz-trachyte with their edges passing into obsidian porphyry. *d*, Pumiceous agglomerates.

The great masses of pumiceous agglomerates, traversed by dykes and sheets of the peculiar quartz-trachyte which together constitute the greater part of Ponza, and the whole of Palmarola, are in Zannone seen in contact with sedimentary rocks of Cretaceous age (Hippurite limestones) resembling those of the nearest point of the mainland, Monte Circello. To the student of the older volcanic rocks those features of local metamorphism presented by the limestones of Zannone, which were first pointed out by Mr. Scrope in 1827, cannot fail to be of the highest interest. On the north-east side of the island the Cretaceous limestones exhibit precisely the same characters as at Monte Circello; but as we approach the igneous masses extruded through them, they are found becoming highly crystalline and by degrees passing into a dolomite. A specimen of this altered rock, which my friend Professor Guiscardi, of the Naples University, examined for me, was found to exhibit little or no effervescence upon the application of acid to it; but when powdered and heated with the acid, carbonic acid gas was at once disengaged.

But not only has the limestone undergone considerable changes near its junction with the igneous rocks, but these latter have also themselves been greatly affected, passing into a compact highly siliceous material, with a strikingly conchoidal fracture. It is interesting to notice that the intrusive rocks of similar composition in the Hebrides have undergone precisely similar changes near their contact with stratified masses.

We have thus evidence that in the Ponza Islands great eruptions of igneous rocks of the most highly acid class have taken place subsequently to the deposition of the Cretaceous rocks, and that after these earlier volcanic masses had suffered greatly from denudation, which appears to have removed all the cones and lava-streams, leaving only masses of agglomerates traversed by dykes and sheets intruded among them, a second series of volcanic outbursts took place. As the result of these latter, at least three volcanic cones, composed of similar materials to those of Epomeo and the older portion of Vesuvius and Somma, were formed—namely, those of which we see the relics in Ventotiene and San Stefano, in the Botte Rock, and in the Monte della Guardia of Ponza, respectively.

The volcanic tuffs (whether of the older or younger volcanic series in the Ponza Islands) have as yet yielded no organic remains; so that some doubt still remains, both as to the conditions under which they were formed, and their exact geological age. The newer trachytic lavas and stratified tuffs are not improbably of the same age as the rocks of identical composition constituting Epomeo and the nucleus of Vesuvius; the older series of rocks of highly acid composition belong to some period between the Cretaceous and the Pliocene.

It is on account of the peculiar and very interesting characters presented by these highly acid or siliceous rocks that the Ponza Islands have attracted so much attention from geologists. The ultimate chemical composition of these rocks is exhibited in the three subjoined analyses, for which we are indebted to Abich. They illustrate three of the most important modifications of character assumed by the rock.

	I.	II.	III.
Silica	73·46	74·54	75·09
Alumina	13·05	13·57	13·26
Oxide of Iron	1·49	1·74	1·10
Oxide of Manganese	trace.	0·10	—
Lime	0·45	0·34	0·18
Magnesia	0·39	0·24	0·16
Potash	4·39	3·68	8·31
Soda	6·28	4·86	1·67
Loss	—	0·20	—
	99·51	99·27	99·77
Specific Gravity	2·5398	2·5293	2·6115

I. is a porphyritic rock with crystals of mica and glassy felspar from Ponza; it represents the more granitic forms of the rock. II. is the interesting, curiously laminated, rock of Palmarola, "the banded and ribboned trachyte" of Mr. Scrope; it contains only traces of mica and hornblende. Abich regards these two rocks as made up of about 50 per cent. of orthoclase, 25 per cent. of free quartz, and 25 per cent. of albite. The small proportion of lime and the large per-centage of soda make it extremely probable that albite is a very important constituent of this rock. III. is a more porous rock from Zannone inclining to the vitreous structure, in which nearly the whole of the felspar appears to be orthoclase, while the free quartz amounts to 28·4 per cent.

The microscopic study of these rocks of Ponza brings to light many features of the highest interest. A series of specimens may easily be collected, exhibiting every variation from a vitreous rock to one of the most highly crystalline character; some of the examples of the latter, indeed, approach so closely in character to *granite* that it is questionable whether they ought not really to be assigned to that class of rocks.

Every attempt, like that of Gustav Rose, to give granite a purely mineralogical definition, has failed, in consequence of the variation, even in different parts of the same mass, in its constituent minerals. The several felspars may replace one another in an almost infinite number of ways, and different micas and hornblendes may be similarly substituted for one another, while accessory minerals may so increase in abundance as to become important constituents of the rock, without its in any way forfeiting the title to be considered a true granite. The *texture* of the rock, however, appears to afford surer ground on which we may base a definition, than the exact species of minerals which compose it. Normal granites consist of an aggregate, in which distinct crystals of orthoclase, and often of some plagioclastic felspar, with those of one or more species of mica or hornblende, have separated, leaving a base composed of quartz, exhibiting a greater or less tendency to form distinct crystals, and a crystalline mass of felsitic matter enveloping the perfect and imperfect crystals, and representing the "mother liquor" out of which these latter have been formed, portions of which are also entangled in their cavities. There are, however, granites in which the quartz appears to have more readily crystallized, and to have been among the first minerals separated from the mass.

Now the remarkable rock of the Ponza Islands has an ultimate chemical composition identical with that of many granites; its constituent minerals—orthoclase albite or oligoclase, quartz and mica or hornblende—are precisely those of ordinary granite; and hence it must be by its *texture*, if at all, that we must hope to be able to separate it from that class of rocks.

The study of this Ponza rock clearly proves that the minerals of which it is composed have had four different modes of origin.

I. They may have crystallized out from a liquefied magma, probably under great pressure, and long before it reached the surface. This is, I believe, the origin of the large crystals of mica, hornblende, felspar, and the smaller and less perfect ones of quartz, which are found scattered, often in great abundance, alike through the most vitreous and the most stony varieties of the rock. In proof of this fact of the formation of large crystals in the magma before its eruption I may cite the following facts.

1. In the masses of volcanic sand blown from the throats of volcanos, crystals (usually of course broken and damaged, but of precisely similar character to those embedded in the lava) abundantly occur. The perfect augite crystals ejected by Stromboli afford an interesting illustration of this fact.

2. Where the lava contains these large porphyritically embedded crystals, the scoriæ or pumice formed from it will be found to contain the same crystals in a perfect condition, entangled in the meshes of the distended rock; clearly proving that these crystals were floating in the liquefied mass before its ejection. This fact is exemplified in many of the pumices and scoriæ of Ischia.

3. These crystals, when embedded in the rock, are often seen to be rounded on their edges and to have suffered other injuries. Sometimes the same crystal is seen broken into several fragments, which are more or less separated from one another. The mica crystals, owing to their perfect cleavage, have often especially suffered; their edges are "frayed-out," their laminæ separated by portions of the matrix which has been forced between them, and occasionally the plates of which they are built up are found to be twisted and crumpled in the most extraordinary manner.

4. Such crystals are all seen to be arranged with their longer axes in the direction of the flow, and around them the smaller crystals, formed by the devitrification of the enveloping mass, exhibit the *fluidal structure* and a peculiar packing or condensation around and behind them. Many of the sections indeed present an appearance which may be justly compared to the surface of a flowing stream, on which at the same time quantities of chaff and a number of pieces of wood are floating; the former representing the microliths, and the latter the porphyritically embedded crystals.

That those conditions of high temperature, great pressure, and the presence of large quantities of imprisoned water and gases, which exist deep down in a volcano, are eminently favourable for the formation of large crystals of various minerals, we have the clearest proof in the beautiful contents of those blocks which are torn from the deep underlying rocks of Vesuvius and ejected from its throat. That the same conditions should induce a similar separation of the materials of the liquefied mass itself, is no more than might be expected. On a future occasion I shall discuss the nature and origin of the condition of fluidity in igneous rocks, upon which so much light is thrown by the fact that crystals of minerals of very different degrees of fusibility are able, not only to separate, but to continue floating about in them.

II. When, as was shown by Mr. Sorby, a granite, like that of Mount Sorrel, is fused, it passes on cooling into a glass. But if the cooling be conducted slowly, *sphærulites* composed of acicular crystals in radial groups are formed in the mass. Now in some cases the matrix surrounding the crystals of the Ponza rock before described has assumed a vitreous condition, and it there becomes a porphyritic obsidian. In this obsidian every variation from the first appearance of crystalline structure to the formation of the most distinct sphærulites may often be observed.

III. If glass be heated to a point far short of that required for its fusion and slowly cooled, crystals of various minerals begin to make their appearance in the mass, which gradually passes into stone, or in other words becomes devitrified. The possibility of this passage from the glassy to the stony condition *without fusion* is a condition which must always be borne in mind by the geologist. The slowness with which large masses of such imperfectly conducting materials, as most lavas are, cool down, is familiar to all who have studied volcanos. It can hardly fail to happen, then, that many lavas which have solidified as glasses have, in the long intervals, during which they have been gradually parting with their remaining heat, become devitrified.

The glassy condition of rocks is clearly an exceptional and *unstable* condition for them to assume. The probable reason why no vitreous rocks of ancient date exist is not because similar conditions of volcanic action did not prevail in earlier periods of the world's history, but because the vitreous rocks have lost their peculiar characters by devitrification. In proof of this conclusion I may recal the fact, already described by me, of Old Red Sandstone lavas in Scotland exhibiting traces of sphærulitic structure, which appears to be in all cases connected with the existence of volcanic glass. Even a moderate degree of heat, if sufficiently prolonged, permits of the passage of a matter from the unstable colloid to the stable crystalline condition; and it is not improbable that pressure and other forces long sustained may be attended with the same result.

The Ponza rock often exhibits clear evidence that after solidifying in the form of a glass it has been subjected to devitrification.

IV. The passage through the rock of water, especially when this contains such acids as abound in volcanic regions, may completely alter the composition and internal characters of the rock. Certain minerals among its constituents may be attacked and removed in solution, while others assume a totally different crystalline condition and arrangement. Of such changes the rock of Ponza often exhibits the clearest evidence, its more basic materials being attacked and destroyed, and its quartz re-crystallized. As shown by Mr. Scrope, veins of quartz and true metallic lodes with cupriferous pyrites occur in this rock; and the quartz of these, as pointed out by Mr. Sorby, is quite different in character from that in the unaltered igneous rock. It contains "many fluid-cavities with water holding in solution the chlorides of potassium and sodium, the sulphates of potash, soda and lime, and free hydrochloric acid."

Let us now proceed to inquire what are the relations of this interesting rock of Ponza to granite, on the one hand, and to the ordinary highly siliceous lavas (quartz-trachytes or Liparites), on the other.

The geological relations of this rock have been so fully illustrated by Mr. Scrope that it is not necessary to dwell at any length upon the subject. Through vast masses of pumiceous agglomerates, evidently formed by explosive action, the solid rock of which we are speaking has been forced in dykes and sheets, which sometimes have a width of a few inches only, at others of many yards. The crushed and re-consolidated character of portions of the matter at the sides of these dykes, the remarkable banded and ribboned internal structure of the rock itself in many places, and the phenomena witnessed at the planes of contact of the dykes with the masses which they traverse, bear witness to the violent force and vast irregular pressures which accompanied their intrusion.

In no case does this more ancient rock of Ponza appear to have been extruded as lava, and to have consolidated under ordinary atmospheric pressure. Either the pressure of the superincumbent ocean, or possibly that of mountain masses of volcanic materials poured out at the surface and piled above them, has evidently influenced their mode of consolidation, and greatly modified their characters.

This conclusion is quite in accordance with the microscopical characters presented by the minerals which compose these rocks. The felspar crystals abound with cavities filled with stony matter; while the crystals of quartz, as pointed out by Mr. Sorby, contain fluid-cavities with air-bubbles, and present a most perfect resemblance to those of the true granitic rocks. The result of Mr. Sorby's most ingenious researches, however, was to show that while the quartz crystals of the Ponza rock must have been formed under a very considerable pressure (one of possibly not less than 4000 feet of rock), yet that the ordinary granites were produced under a pressure which must have been far greater.

Great, indeed, as are the points of resemblance between the rock of Ponza and many granites, both in chemical and mineralogical constitution, and in certain features of their microscopic structure, the real and important points of difference between these two classes of rock must not be lost sight of. These differences consist in the tendency which the *basis* of the rock constantly shows to assume the vitreous condition, and in the mode of arrangement and injured condition of its embedded crystals. In these respects the rock of Ponza approaches and even graduates into the ordinary highly siliceous lavas (Quartz-trachytes, Liparites or Rhyolites), such as those which we have described in the Lipari Islands.

Thus we are led to the conclusion that rocks like those of Ponza, and certain others in the Euganean Hills, Hungary, etc., which precisely agree with them in character, form a perfect bond of connexion between the granites on the one hand and the highly siliceous lavas (Liparites) on the other. For rocks of this character Richthofen has suggested the name of "granitic-rhyolite," or "Nevadite," and his definition of this rock, which constitutes great mountain masses in the western parts of North America, appears to be entirely applicable to the rock of Ponza. Whether geologists agree to accept this term or not, the fact remains of the existence of a series of rocks through which we can trace the passage, by the most insensible gradations, from *granite* to the variety of *lava* known as Liparite.

It has been shown by Delesse, Durocher, and other observers, that a rock of highly crystalline or granitic structure has a much higher specific gravity than the glass formed by its artificial fusion. As both mathematical reasoning and experiment have led Sir William Thomson and his brother to the conclusion that for those bodies which contract in consolidation pressure raises the point of fusion, while for those that expand it lowers it, we might by analogy be justified in inferring that, under great pressure, rocks would be unable to undergo that expansion necessary for their assuming the colloid or vitreous condition. I need not point out how this conclusion coincides with the observations of the geologist. We have the strongest grounds for inferring that in granite consolidation took place under enormous pressure; and we never find it assuming the vitreous structure. In the rock of Ponza the pressure was evidently far less, and the rock occasionally passes into a more or less glassy form; while in the *lavas* known as Liparites, where all superincumbent pressure is got rid of by their extrusion at the surface, the tendency to pass into the vitreous condition is, as we have seen, extreme. By the study of different portions of igneous masses we are able, therefore, to trace every stage in the transition from the most typical granite to the most perfect glass and pumice.

The relation of the glassy portions of the rock of Ponza to the ordinary crystalline varieties are, as pointed out by Mr. Scrope, worthy of the most careful study. In almost every case the dykes or intrusive sheets of crystalline rock are at their planes of junction converted for a greater or less thickness into a glassy material. Three different causes suggest themselves as possibly tending towards this result.

(1). The more rapid cooling of the liquefied masses on their outer surfaces.

(2). The enormous friction, of which we have the clearest evidence, between the intruded matter and the agglomerates through which they were forced. This might operate in two ways: by crushing up the solidifying particles, and rendering them easy of refusion; and by the actual development of additional heat from the friction. The probability of this kind of action having gone on is shown by the fact that not only are the dykes of solid rock converted into glass at their sides, but the masses of agglomerate themselves, near the lines of junction, also pass into obsidian.

(3). The smaller amount of resistance offered by the agglomerates to the expansion, which, as we have seen, takes place in the passage from the crystalline to the colloid state, would favour the production of obsidian on the outer surfaces of the intrusive masses.

It may well be conceived how, with the presence of such conditions as we have indicated, the most remarkable transitions of rock structure from the glassy to the crystalline may be produced; accompanied by the development of the most singular examples of brecciated, ribboned, and contorted appearances.

There are a number of other interesting features which have been already described as being exhibited by the Ponza rocks, to which want of space will prevent us from doing more than making the barest allusion in this sketch. Such are the interesting prismatic forms assumed by them on the smallest as well as on the largest scale; the remarkable globiform concretions in some of their vitreous masses; the changes undergone by them in consequence of the passage of water and acid gases through them; and the formation of crusts of carbonate of lime on their surfaces, and of calcareous sandstones in their hollows, through the agency of land-shells. For details on these subjects I must again refer to Mr. Scrope's memoir. The causes of the production of the banded structure in these rocks I shall have occasion to discuss on a future occasion.

In concluding this imperfect sketch of a district, which, among those which have been carefully examined by geologists, is almost without a parallel in respect of the features of interest which it affords, I may refer to two points of some novelty which came under my notice. Occasionally, in consequence of the extreme pressure, the obsidian on the sides of the dykes has assumed a most remarkably *fibrous* structure, such as has not, so far as I am aware, been observed in this rock at any other locality. A second curious fact was one which I was struck with in breaking up some of the great masses of obsidian, namely, that the bright glassy surfaces of fracture only endured for a few seconds after their exposure; a delicate white film, doubtless due to the exudation of some crystalline matter on their surfaces, being formed upon them actually under the eye of the observer.

(To be concluded in our next Number.)

IV.—Lists of some English Jurassic Foraminifera.

By Professors T. Rupert Jones, F.R.S., F.G.S., and W. K. Parker, F.R.S., F.Z.S.

THE late Professor John Phillips requested us to draw up, for an Appendix to his new edition of "The Geology of Yorkshire," a generic list of the Foraminifera of the English Oolites. He had himself, indeed, supplied us with some good material from the clays near Oxford. We have noted the following Foraminifera from the Lower Oolite, Oxford and Kimmeridge Clays, and the Portland Limestone, in our collection.

The Foraminiferal Fauna here indicated is comparable with that of Switzerland, reviewed at p. 213, Vol. X. Geol. Mag. (May, 1873), though not so rich in *Miliolæ,* and wanting some other genera. M. O. Terquem's still more richly illustrated memoirs on Oolitic Foraminifera (Metz, 1867-70), place before the eyes an enormous collection of similar Microzoa;[1] and the Rev. J. F. Blake's memoir on the Kimmeridge Clay, lately read before the Geological Society of London, enumerates numerous forms of the same group.[2]

1. Upper Portland Limestone, Ridgeway, Dorset.

Lagena globosa.
Cristellaria rotulata.
Trochammina (combining the characters of *Tr. gordialis* and *Tr. incerta*; low-conical, having irregular chambers within annular chambers, sub-translucent).

2. Kimmeridge Clay, Aylesbury.

Foraminifera.
Glandulina.
Nodosaria.
Dentalina.
Vaginulina (*V. harpa*).
Marginulina.
Cristellaria.
Planularia.
Lituola (nautiloid).

Polyzoon:—Lepralia.

3. Kimmeridge Clay, Kimmeridge, Dorset.

Lagena (*L. globosa,* var., simple, oval, without neck).
Lingulina.
Dentalina.
Vaginulina (*V. harpa*).
Marginulina.
Cristellaria.
Pulvinulina (*P. caracolla*).
Textularia (*Plecanium;* small, long, rough).
Lituola (straight).
Trochammina incerta.

[1] See also Annals Nat. Hist. series 4, vol. viii. pp. 363-365.
[2] Quart Journ. Geol. Soc. vol. xxxi. p. 222.

4. *Ostrea-deltoidea* bed, lower part of the Kimmeridge Clay, at the base of Shotover Hill, near Oxford.

Dentalina.
Vaginulina (*V. harpa* and *V. lævigata*).
Marginulina.
Cristellaria.
Planularia.
Flabellina.
Frondicularia.
Lituola (*Placopsilina*; attached, creeping, nearly straight).
Lituola globigeriniformis.

5. Upper Oxford Clay, Oxford.

Orthocerina (*Rhabdogonium*; triangular)
Lingulina (some with terminal Nodosarian chambers).
Dentulina (very delicate and long).
Vaginulina (*V. harpa*).
Marginulina.
Cristellaria.
Planularia.
Flabellina.
Frondicularia.
Lituola (straight, lituate, and nautiloid).

6. Oxford Clay, Ridgeway, Dorset.

Marginulina.
Cristellaria.
Pulvinulina caracolla.
Lituola (nautiloid and lituate).

7. Shelly Clay, Lower Oolite, on the Deeping Road, 1½ mile N. of Peterborough.

Nodosaria.
Dentalina.
Vaginulina (*V. harpa* and *V. strigilata*).
Marginulina.
Planularia.
Cristellaria.
Flabellina.
Frondicularia.
Textularia (*Plecanium*).
Verneuilina.
Lituola (straight, lituate, and nautiloid).
Trochammina (*Webbina*; creeping, attached to a shell).
Tr. incerta (both sandy and sub-translucent).
Nubecularia (attached, long, moniliform, on shell).

The specimens in No. 7 were obtained by one of us from shelly tenacious clay between the thin limestones dug for road-metal at a spot called "Style's Close," at the north corner of the junction of Dogsthorpe Lane with the Deeping Road, 1½ mile north of Peterborough, just where the figures "83" occur on the Ordnance Map.

On the other or west side of the Deeping Road, opposite to Style's Close, and, like it, within the "Walton Fields," is the railway settlement called "New England." From a well here, at the depth of 150 feet, a piece of Upper Lias yielded as follows:

8. Upper Lias Clay, from a depth of 150 feet, at New England, near Peterborough.

Cristellaria.
Pulvinulina (between *P. elegans* and *P. caracolla*); small and abundant.
Lituola scorpiurus (dentaline and neat).
Trochammina incerta (*Tr. elliptica*; oblong-oval).

To illustrate the relative position of the Foraminifera-bearing beds near Peterborough, mentioned above, the subjoined list of the Oolite beds in the neighbourhood of Peterborough, from notes by Mr. J. W. Judd, F.G.S., will be of service to the collector,[1] for doubtless very much more is to be done with the Jurassic Foraminifera.

1. Lower part of the Oxford Clay; very dark blue shales, with shells. Stanground, Fletton, and Woodstone brickyards.

[1] "The Geology of Peterborough and its Vicinity," by the late Dr. Henry Porter (8vo., Peterborough, 1861), may be consulted for some useful details as known at that date.

2. Kellaways Rock; sandy clay and sandrock; very shelly in places. Dogsthorpe brickyard.
3. Cornbrash, 15 feet; limestone.
4. Great Oolite Clays, 20 feet; dark-blue and greenish clays, with shelly bands. New England brickyard, Orton railway-cutting, and in many wells.
5. Great Oolite Limestone, 25 feet; with marly or clayey bands and partings, very shelly. Railway-cuttings at Orton, and in wells.
6. Upper Estuarine Series, 15 feet; blue and green clays, with many very shelly bands. In wells.
7. Sands and Clays of the Lower Estuarine Series, and the Northampton Sand or Inferior Oolite, 20 feet; in deep wells.
8. Upper Lias Clay, of the usual character; in the deepest borings.

In many parts of the neighbouring Fens may be found the "buttery clay," of Pliocene or Sub-recent date, from which one of us long ago obtained and determined many interesting Foraminifera; see Mr. H. B. Brady's memoir on Estuarine Foraminifera in the *Annals Nat. Hist.* 4, vi. pp. 305–6.

We may add that we have also seen from the Kimmeridge Clay:—

Polymorphina lactea, Trans. Lin. Soc. xxvii. p. 215.
——— *gibba*, Trans. Lin. Soc. xxvii. p. 218.
——— *compressa*, Trans. Lin. Soc. xxvii. p. 229.
Bolivina punctata, Phil. Trans. clv. p. 376.
Pulvinulina elegans, var., Phil. Trans. clv. p. 390.
——— *Karsteni*, var., Phil. Trans. clv. p. 397.

From the Oxford Clay:—

Polymorphina compressa, Trans. Lin. Soc. xxvii. p. 229.
Bolivina punctata, Phil. Trans. clv. p. 376.
Pulvinulina Karsteni, var., Phil. Trans. clv. p. 397.

From some clays of the Oolites:—

Virgulina Schreibersii, varieties, Phil. Trans. clv. p. 375.
——— *paradoxa*, Ann. N. H. 4, xix. p. 299.
Textularia (Spiroplecta) annectens, Ann. N. H. 3, xi. 92, 96.

From "Speeton Clay" (= ? Kimmeridge Clay):—

Pulvinulina caracolla (large) in both Dr. Bowerbank's collection (formerly), and in the Museum Pract. Geology (Tablet XI$\frac{4}{1}$).

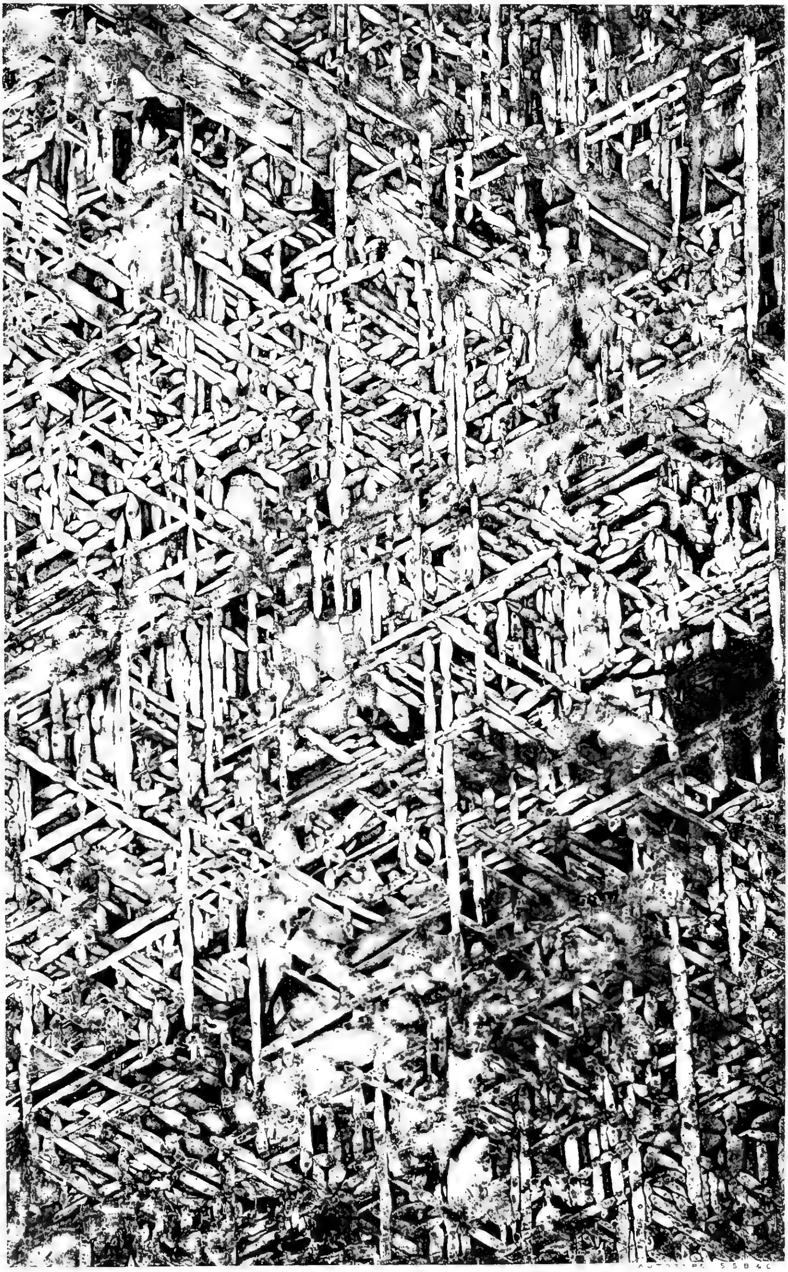
As a general list for the Oolitic Foraminifera of Europe we offer the following:—

Lagena.
Nodosaria.
Glandulina.
Dentalina.
Lingulina ?
Orthocerina.
Vaginulina.
Marginulina.
Cristellaria.
Planularia.
Flabellina ?
Frondicularia.
Polymorphina.
Bulimina.
Bolivina.
Virgulina.
Textularia.
Verneuilina.
Spiroplecta.

Orbulina.
Globigerina ?
Carpenteria ?
Spirillina.
Planorbulina.
Pulvinulina.
Nonionina ?
Nummulina.

Trochammina.
Webbina.
Involutina.
Endothyra.
Saccammina.
Lituola.
Placopsilina.
Cornuspira ?
Nubecularia.
Miliola.

These are nearly all *Liassic* also; and in the Lias moreover



METEORIC IRON, FROM TOLUCA, MEXICO.
Polished Surface etched with Bromine.
[Actual Size.]

Orbitolites has been found by Gümbel (see the GEOLOGICAL MAGAZINE, Vol. X. p. 82).

The Foraminiferal faunæ of the Rhætic and the Trias, as far as known, are very similar to the Jurassic. See the GEOLOGICAL MAGAZINE, Vol. VII. p. 180.

V.—A CHAPTER IN THE HISTORY OF METEORITES.

By WALTER FLIGHT, D.Sc., F.G.S.

Of the Department of Mineralogy, British Museum;
Assistant Examiner in Chemistry, University of London.

(PLATE IX.)

(*Continued from page* 267.)

1776.—Krasnojarsk, Siberia. (The Pallas Iron.) [1]

This celebrated siderolite has recently been sawn into two nearly equal parts, and the occasion presented a fitting opportunity for an exhaustive examination of its constituent minerals, more especially of the olivine forming the chief ingredient. It was accordingly undertaken by von Kokscharow, at the desire of the Imperial Academy of Sciences, and his memoir is mainly devoted to a description of the crystallographic characters of the silicate enclosed in the nickel-iron.

He finds that the interior presents no new leading features. The olivine, which has a greater number of crystal-faces than Pallas observed on it, occurs not only in spherular or drop-like masses bearing numerous faces, but in tolerably well-developed crystals, which, though rounded here and there, exhibit sharp edges, and a considerable number of forms, some of which have not been observed on terrestrial olivine. The individual crystal has generally a rounded surface, on which the planes lie; and although these are separated from each other by curved areas, their mutual inclination enables the observer to identify them. They are in most instances smooth and lustrous, and allow of the most accurate goniometrical measurement being performed. The best developed faces are: $c = o\,P$; $d = \overline{P}\ \infty$; and $o = \frac{1}{2}\,P$. Biot [2] showed half a century since that these rounded masses of olivine exhibit crystalline structure, and possess two optic axes. The first minute investigation of them was conducted by G. Rose.[3]

Rose observed eleven crystal-forms on the Pallas olivine; von Kokscharow has added eight more, making nineteen altogether, which are as follow:

[1] N. von Kokscharow. *Bull. l'Acad. Imp. Sc. St.-Pétersbourg*, 1870, xx., No. 3. *Mémoires l'Acad. Imp. Sc. St.-Pétersbourg*, xv., No. 6 *Jahrb. Mineralogie*, 1870, 778.—E. H. von Baumhauer. *Archives Néerlandaises*, 1871, vi.—G. von Helmersen. *Zeitsch. Deutsch. Geol. Gesell.* xxv., 347.

[2] J. B. Biot. *Bull. de la Soc. Philomatique*, 1820, 89.

[3] G. Rose. *Pogg. Ann.*, 1825, iv., 186.

Rhombic Pyramids.

	Weiss.	*Naumann.*
q ...	$(a : 6b : 6c)$ ...	$\frac{1}{6}P$
o ...	$(a : 2b : 2c)$ ...	$\frac{1}{2}P$
e ...	$(a : b : c)$ ...	P
a ...	$(a : \frac{n}{m}b : \frac{1}{m}c)$ ...	$m\bar{P}n$
f ...	$(a : \frac{1}{2}b : c)$ ...	$2\breve{P}2$
l ...	$(a : \frac{1}{3}b : c)$ ...	$3\breve{P}3$

Rhombic Prisms.

n ...	$(\infty a : b : c)$ ...	∞P
s ...	$(\infty a : \frac{1}{2}b : c)$ ...	$\infty\breve{P}2$
r ...	$(\infty a : \frac{1}{3}b : c)$ ...	$\infty\breve{P}3$

Macrodomes.

β ...	$(a : \infty b : 6c)$ ...	$\frac{1}{6}\bar{P}\infty$
v ...	$(a : \infty b : 2c)$ ...	$\frac{1}{2}\bar{P}\infty$
γ ...	$(a : \infty b : \frac{1}{m}c)$ ...	$m\bar{P}\infty$
d ...	$(a : \infty b : c)$ ...	$\bar{P}\infty$

Brachydomes.

w ...	$(a : 2b : \infty c)$ ...	$\frac{1}{2}\breve{P}\infty$
h ...	$(a : b : \infty c)$ ...	$\breve{P}\infty$
k ...	$(a : \frac{1}{2}b : \infty c)$ ...	$2\breve{P}\infty$
i ...	$(a : \frac{1}{4}b : \infty c)$ ...	$4\breve{P}\infty$

Pinacoids.

a ...	$(\infty a : b : \infty c)$ ...	$\infty\breve{P}\infty$
c ...	$(a : \infty b : \infty c)$ ...	oP

The forms *e, f, l, n, s, r, d, k, i, c,* and *a,* are those described by Rose; the remainder were not only previously unknown on Pallas olivine, but, with the exception of *h* and *w*, have not been met with on chrysolite from any locality. The brachydome *w* has recently been noticed by vom Rath[1] on the olivine of the Laachersee sanidine. Although the crystal-faces of the Pallas olivine are somewhat numerous, $\bar{P}2$, noticed by Descloizeaux,[2] and $\infty\breve{P}4$, as well as the macropinacoid $b = \infty\bar{P}\infty$ of other observers, have not been noticed. In two of the plates accompanying the memoir the author gives eight projections of the more important combinations of the above forms, while in a third plate they are all graphically represented according to Neumann and Quenstedt's method.

On comparing his measurements of the faces of the Pallas olivine with the numbers obtained by Mohs, von Haidinger, Scacchi,[3] and himself, when examining crystals of olivine from other sources, the author finds almost complete accordance between them, and deduces the following numbers for the axes of the olivine crystal:

$$a = 1{\cdot}25928$$
$$b = 2{\cdot}14706$$
$$c = 1{\cdot}00000$$

He then proceeds to establish their correctness by comparing in detail the calculated values with those obtained by measuring the meteoric olivine, and that from Egypt and Vesuvius, as well as specimens of the mineral from other localities, investigated by Mohs and von Haidinger.

Rose[4] was the first to observe under the microscope the remarkable structure of this olivine. On examining a section, $2\frac{1}{2}$ mm. in thickness, he noticed, even with very low powers, that it was traversed by a number of straight black lines lying parallel to each other; so

[1] G. vom Rath. *Pogg. Ann.*, 1868, cxxxv., 580.
[2] A. Descloizeaux. *Manuel de Minéralogie*, i., 30.
[3] A. Scacchi. *Pogg. Ann.*, *Ergänzungsband* iii., 184.
[4] G. Rose. *Beschreibung und Eintheilung der Meteoriten*, Berlin, 1864, 75.

sharp and regular were they, that they resembled lines described on paper with a drawing pen. When magnified 200 to 300 diameters, they appeared to be tubes, sometimes empty, sometimes filled more or less with a black or light grey substance, or both substances. In one crystal with two small faces *k*, and between them the face *a*, it was noticed that the faces *a* and the tubes reflect light at the same instant, and that they lie at right angles to the axis of the zone *ka*.

Von Kokscharow found these canals in every granule of the Pallas olivine which he examined; one crystal, 6 mm. in diameter, through which a section was cut, exhibited 17 of them under a pocket lens, and many more in the microscope; they were all parallel to the edge *s r*, that is to say, parallel to the vertical crystallographic axis. A mean of nine measurements of the angle which these canals form with the edge *e a* (which were made with a very good goniometer, designed by von Auerbach and constructed by Hartnack) was found to be 38° 28′, the calculated angle being 38° 27′ 12″. The plane of the optic axes lies at right angles to the canals, and therefore to the crystallographic vertical axis; in short, this plane in Pallas olivine, as in the terrestrial specimens, is parallel to the basal pinacoid *c* = o P.

The canals were studied in seven sections of crystals, and drawings of them are given in a plate. By altering the focus of the microscope, canals lying at various depths are brought into view; when a certain thickness of the olivine has been traversed, the doubly-refractive power of the intervening layer of the mineral causes the canals to appear double. Another effect of this property of the crystal is that the magnifying power of the microscope is also apparently somewhat increased. The partial overlapping of the two images of a canal gives it the appearance of a tube filled throughout the entire length with black material; others, again, viewed through greater thicknesses of the mineral, appear as two distinct tubes. Examination with a Nicol or a tourmaline plate at once convinces the observer that these effects are due to double refraction.

The enclosed black and grey matter is found sometimes at one end only of a tube, sometimes in the middle, or again at different points in its length, in which case it presents the appearance of a thermometer, the mercurial column of which has been broken. Other sections are described which were prepared so that the tubes were cut obliquely, or at right angles. The results of an examination of these sections in polarized light supports the assumption that these appearances are caused by hollows traversing the olivine, and not by transparent crystals enclosed in it.[1]

This olivine has been investigated chemically by Howard, Klaproth, Stromeyer, Walmstedt, and Berzelius. It has recently been

[1] It should be mentioned that Rose (*Beschr. und Einth. Met.*, 76) found these canals in great perfection and abundance in the olivine of the meteorite found at Brahin, Minsk, Russia (1810), a siderolite bearing the closest resemblance to the Pallas iron. The mineral occurring in the siderolites of Rittersgrün and Steinbach, which Rose termed olivine, and some of the angles of which he found to accord with those of the olivine of the Pallas and Brahin siderolites, is probably not olivine, but bronzite.

examined by H.I.H. the Grand-Duke Nikolai Maximilianovitsch von Leuchtenberg; the mean numbers resulting from his analyses are given under I. Von Baumhauer, to whose paper we shall immediately turn our consideration, also publishes a new analysis of this silicate (II.), and gives in juxtaposition the theoretical numbers (III.) corresponding to an olivine of the formula:

$$2\,FeO,\ SiO_2 + 7\ (2\,MgO,\ SiO_2).$$

	I.	II.	III.
Silicic acid	40·24	40·87	40·70
Magnesia	47·41	46·93	47·17
Iron protoxide	11·80	12·11	12·13
Nickel protoxide	...	trace	...
Manganese protoxide	0·29	trace	...
Alumina	0·06	...	...
Tin Oxide	0 08	...	...
	99·88	99·91	100 00

Rumler found arsenic in this silicate, and Howard half a per cent. of oxide of nickel. The Duke of Leuchtenberg discovered none of this oxide in the specimens which he examined. It is not improbable that Howard may have fallen into error through the presence of organic matter in the ammonia, employed in his analysis, having rendered the precipitation of the iron oxide incomplete.

Von Kokscharow finds the specific gravity of some very pure crystals of the olivine to be 3·3372; of some brown fractured granules, 3·3415; the mean being 3·3393.

Many terrestrial olivines contain nickel protoxide. Rammelsberg found 2·35 per cent. in the variety of this mineral occurring in the basalt of Petschau, in Bohemia; Genth determined its presence in that from Thjorsalava, of Hekla; and Sartorius von Waltershausen in the olivine of the Fiumara di Mascali, near Etna. It has also been detected in the olivine of Langeac, Haute-Loire; it forms a constituent of that mineral as met with in the lherzolite of the Pyrenees, in the lava of the Isle of Bourbon, in the basalt of Sneefels-Jockul, Iceland, in the melaphyre of Oberstein, and in the dunite of Mt. Dun, New Zealand. A knowledge of these facts induced von Baumhauer to examine with great care the Pallas olivine for nickel.

That portion of a meteorite which, after the nickel-iron has been removed with a magnet, dissolves in acid, is usually regarded as olivine, $2\ RO,\ SiO_2$. Small quantities of alumina, lime, manganese, and nickel protoxide, and occasionally of alkalies, are, it is true, also found in the solution; but with the exception of the nickel oxide, the occurrence of which is ascribed to the incomplete removal of the nickel-iron by the magnet, the presence of these ingredients is attributed to the incipient decomposition, even in the cold, of the other silicates of the meteorite.[1] Mercury chloride, a reagent the use of which was proposed by Rammelsberg, enables us to separate by solution the nickel-iron from all the silicates. The sublimate, however, does not

[1] It has been found that the enstatite of the Busti meteorite (which see) is slowly decomposed by hydrochloric acid.

dissolve any portion of the nickel-iron which by oxidation may have been converted into hydrated oxide of iron and oxide of nickel. To remove them von Baumhauer heats the powder, which has previously been treated with the chloride, in a current of hydrogen, and, after reducing the oxides to the state of metal, subjects the powder once or twice more to the action of the sublimate in an atmosphere of hydrogen. By careful selection and treatment in the above manner, he proceeded to operate on some apparently pure olivine from the Pallas meteorite; it was of a clear yellow colour, and, when heated for half an hour in hydrogen, lost no weight. It was then broken up with acid, and analysed by the usual method; the iron oxide retaining any nickel oxide that may be present was twice dissolved in acid and thrown down with ammonia. The three filtrates, containing all the magnesia, were treated with ammonium sulphide, which produced a black precipitate, so small in quantity that it could not be weighed. Before the blowpipe it displayed the characteristics of a compound of nickel.

Von Baumhauer expresses a doubt whether the nickel may not have been a constituent of a trace of the metallic alloy which, in spite of all precautions, may have adhered to the silicate. It is, moreover, a question whether the repeated precipitation of the iron oxide with ammonia, even in the presence of a large excess of ammonium chloride, would effect the removal of a very small proportion of nickel oxide in so complete a manner as Field's method with lead oxide.[1]

In May, 1873, von Helmersen addressed a letter to G. Rose, stating that several members of the Academy of Sciences of St. Petersburg, Schmidt, Schrenck, von Kokscharow, himself and others, had advised the Academy to institute an inquiry into the nature of the ground of the locality where the Pallas siderolite was found, they being of the opinion that such an investigation might throw light on its history, just as an examination of the rocks of Disko had proved of great value in facilitating the study of the Ovifak meteorites. Lopatin, a mining engineer stationed in Eastern Siberia, was directed to proceed to Krasnojarsk for that purpose; the result of his explorations has apparently not yet been published. According to Mettich's report, a very rich iron ore is found on the hill and close to the spot where the Pallas siderolite was discovered.

The Mexican Meteorites.[2]

In continuation of his earlier papers on the meteorites of the Mexican Republic, which appeared in 1856, 1857, and 1858, the late Dr. Burkart has brought the history of these remarkable masses down to the date 1874. He first directs attention to the masses

[1] F. Field. *Chem. News*, i. 4.

[2] C. Rammelsberg. *Zeitsch. Deutsch. Geol. Gesell.*, 1869, xxi., 83.—J. L. Smith. *Amer. Jour. Sc.*, 1869, xlvii., 383; *Amer. Jour. Sc.*, 1871, i. 335.—S. Meunier. Thèse presentée à la Faculté des Sciences de Paris, 1869. *Recherches sur la composition et la structure des Météorites*, 42 *et seq.*—H. J. Burkart. *Jahrb. Mineralogie*, 1870, 673; 1871, 851; and 1874, 22.

found near Santa Rosa, a small town in the N. part of the State of Cohahuila, in lat. 27° 55′ N. and long. 2° 16′ W. of Mexico, and near the boundary of the Bolson of Mapimi.

According to the report of Major E. W. Hamilton, published by Shepard, the spot where he discovered a number of masses of meteoric iron is called Bonanza, 30 to 40 miles north, and much further west of Sta. Rosa. Here Hamilton found scattered over an area, one to two miles in diameter, thirteen blocks of iron, twelve of which had never been shifted; the other, weighing 75 lbs., was about to be sent to Sta. Rosa. The largest, a more or less rounded block, is three feet wide and two to two and a half feet high; others were estimated to weigh from two to three thousand pounds.

Meteoric masses found in the neighbourhood of Sta. Rosa are mentioned by J. L. Smith, and a fragment of one of them was exhibited at the meeting of the American Association for the Advancement of Science held at Chicago in 1868. It appears that Dr. Butcher obtained from the son of Dr. Long, who had resided many years in Sta. Rosa, an interesting account of a very brilliant meteor which in the fall of the year 1837 passed over the town in a N.W. direction; shortly after its disappearance over the mountains a rumbling sound was heard, followed by a tremendous explosion. The next day Mr. Long endeavoured to find traces of the meteorite, but after two days' severe and rough riding the search was abandoned. Shortly afterwards an Indian brought into Sta. Rosa a piece of what he believed to be silver, weighing ten to twelve pounds, stating that it had been found ninety miles N.W. of the town; this proved to be meteoric iron. Dr. Butcher, after this long lapse of time, determined to renew the search, and, hiring eight Mexicans and two Indians as guides, succeeded in finding the irons about ninety miles from Sta. Rosa. They consist of six masses, weighing 290, 430, 438, 550, 580, and 654 lbs., which have been sent to the museums of the United States, and two other blocks, weighing 353 and 450 lbs., which have since been hit upon.

This interesting group of meteoric irons consists of compact metal containing no silicate; it is not difficult to cut with the saw, has the specific gravity 7·692, and the composition:

Iron = 92·95; Nickel = 6·62; Cobalt = 0·48; Phosphorus = 0·02;
Copper = trace. Total = 100·07.

Although these irons differ as regards the amount of nickel they contain from the meteoric iron of Santa Rosa described in 1855,[1] J. L. Smith believes that the disparity arises from an error in the earlier analysis, and that it will be found that the Santa Rosa iron belongs to the above group.

The question which next arises is,—Are the two finds, described by Hamilton and Butcher, one and the same? Burkart, after carefully weighing the evidence of both accounts, allowed that there is much to favour the assumption, and suggested that Shepard and J. L. Smith would do good service to science by referring the subject to the consideration of the two observers.

[1] O. Buchner. *Die Meteoriten.* Leipzig, 1863. Page 192.

J. Guillemin Tarayre[1] in his *Notes archéologiques et éthnographiques*, while describing the *Casas grandes de Chihuahua* or *Malintzin*, mentions the discovery by Müller, the Director of the Mint at Chihuahua, of a meteorite in the great temple north of Galeana (lat. 30° 22′ N.; long. 110° W. of Paris). While excavating these labyrinthine ruins a lenticular piece of iron, 50 cm. in diameter, was discovered carefully enveloped in cloth similar to that in which the dead of the surrounding graves were wrapped.

Among new meteoric stones found in Mexico must be mentioned the chondritic meteorite described by Wöhler; it is stated that it fell in 1855 or 1856 at the Hacienda Avilez, not far from the mining town of Cuencamè, twenty leagues N.E. of Durango in lat. 24° 47′ N. and long. 4° 8′ W. of Mexico.

The large meteoric iron, computed to weigh 19,000 kilog., which lay in the neighbourhood of Durango in Humboldt's time, and of which he brought fragments to Europe that were analyzed by Vauquelin and Klaproth, appears since then to have been lost. Burkart, however, considered some statements made by Guillemin Tarayre in the *Archives de la Commission scientifique du Mexique* to indicate that within the last few years it had again been found near the Cerro Mercado. According to more recent accounts, the locality of this colossal mass is known, but is kept secret, as the owner intends to endeavour to transport it to Mexico.

Burkart briefly notices: the meteoric iron from San Francisco del Mezquital, in the State of Durango, weighing seven kilog., which was described by Daubrée; a piece of meteoric iron[2] "from Mexico," the locality not being more definitely given, which J. L. Smith found to exhibit very distinct figures when etched, and to be composed thus:

Iron = 91·103; Nickel = 7·557; Cobalt = 0·763; Phosphorus = 0·020; with traces of Copper and Sulphur. Total = 99·443.

a meteoric iron at Los Zapotes, four leagues from Cuquio, which is reported to have been brought from Zacatecas; and the meteoric iron of Yanhuitlan (lat. 17° 35′ N.; long. 1° 45′ W. of Mexico), which was in the possession of the Emperor Maximilian, and possibly comes from the same locality as the Misteca Alta iron preserved in some collections. The last two masses contain:

	Yanhuitlan.	Misteca Alta. I.	Misteca Alta. II.
Nickel	6·21	4·39	9·919
Cobalt	0·27	0·18	0·075
Insoluble residue	trace	0·20	—

The first two analyses are by Rammelsberg, the last by Bergemann.[3]

[1] *Archives de la Commission scientifique du Mexique.* Paris, 1869. iii. 348.

[2] This was probably a fragment of the Charcas meteoric iron which General Bazaine sent to Paris.

[3] Burkart gives the following list of localities of meteorites found in the Mexican Republic:—*Meteoric Stones.* 1). Hacienda de Bocas, N. of San Louis Potosi, fell 1804, November 24th. 2). Cerro Cosina, near Dolores Hidalgo, District of San Miguel in the State Guanajuato, fell 1844, January —, 11 A.M. 3). Hacienda Avilez, near Cuencamè in the State Durango, fell 1855 or 1856.—*Meteoric Irons* (each locality lies to the north of those following it in the list). 1). The Casas grandes de Malintzin, between Galeana and Corralites, District Bravos, State of

The last paper written by the late Dr. Burkart gives the history of the meteoric iron from Descubridora, Poblazon, near Catorze, State San Louis Potosi, to which we have already alluded (see page 218). It was found between 1780 and 1783; in 1856 it was conveyed to the Amalgamation Works near Catorze to be used in the *morteros* or stamping mills; and in 1871 was removed to Mexico, where it came into the possession of the Geographical and Statistical Society. In 1872 this learned body came to a determination that the meteorite, which weighs 575 kilog., should be broken up for examination, which drew from the Mexican Natural History Society an indignant protest. Those who take an interest in the correspondence which passed between the two Societies will find below references to the journals in which it appeared.[1] A portion of this iron is one of the most recent additions to the University Collection at Göttingen.

The iron, of which the author gives three drawings, is in the form of a prism with rounded ends, and has a length of 90 cm. It has a steel-grey colour, takes a high polish, and is remarkably malleable: nails, knife-blades, wire, and a watch spring have been made of it. When etched it developes good figures, of which a sketch is given in Burkart's paper; they resemble those of the iron of Xiquipilco; the angle 109° corresponding to an octahedron is frequently noticed. Rounded masses of troilite occur here and there; the hardness is = 8; the specific gravity = 7·38. It has been analyzed by Patricio Murphy with the following results:

Iron = 89·51; Nickel = 8·05; Cobalt = 1·94; Sulphur = 0·45; Chromium and Phosphorus — Traces. Total = 99·95.

A very careful investigation has been made of the physical properties of the wire forged from this iron; it possesses an unusually high elasticity, the modulus being = 7436·17 kilog.; the resistance of the iron to rupture by compression = 38 kilog., to rupture by extension = 40 kilog. In each case the sectional area of the metal operated on was 1 mm. square. The coefficient of the linear expansion of the iron when heated between 0° and 100° C. = 0·00002336783.

Meunier has investigated two of the Mexican irons, those from Charcas and the Toluca Valley. A perfectly clear surface of the Charcas iron appears to be naturally passive. A drop of copper sulphate, if allowed to evaporate at ordinary temperatures on its surface,

Chihuahua. 2). Bonanza, State of Cohahuila. 3). Sierra Blanca, near Huajuquillo (or Jimenez), State of Chihuahua. 4). San Gregorio, State of Chihuahua. 5). Hacienda Concepcion, on the Rio Florido, State of Chihuahua. 6). Hacienda Venagas, probably in the State of Chihuahua. 7). Plain near el Mercado mountain, N. of Durango, State of Durango. 8). Durango (block used as an anvil; this mass has recently been removed to Mexico). 9). San Francisco del Mezquital, State of Durango. 10). Descubridora, at Poblazon, near Catorze, State of San Louis Potosi. 11). Charcas, State of San Louis Potosi. 12). Zacatecas. 13). A Hacienda south (?) of Zacatecas. 14). Xiquipilco, Hocotitlan, Istlahuaca, etc., in the Toluca or Lerma Valley, State of Mexico. 15). Chalco, Valley of Mexico. 16). Misteca Alta, State of Oaxaca. 17). Yanhuitlan, State of Oaxaca. 18). (?) Rincon de Caparosa, near Chilpancingo, on the road to Acapulco.

[1] *Boletin de la Sociedad de Geografia y Estadistica de la Republica mexicana.* Seg. Ep. Mexico, 1872. Tomo IV. Pages 5 and 317.—*La Naturaleza Periodico cientifico de la Sociedad mexicana de Historia natural.* Mexico, 1873. Tome II. Pages 277 and 286.

yields unchanged blue crystals of the salt. The alloy is of the kind to which von Reichenbach gave the name of kamacite, consisting of:

Iron = 92·0; Nickel = 7·5; Total = 99·5.

which corresponds with the formula Fe_{14} Ni.

The compounds of iron with sulphur which occur in meteorites appear to be sometimes magnetic pyrites, sometimes troilite (iron monosulphide). Meunier finds the sulphides of these two irons to have the composition given below. Side by side with the numbers resulting from his analyses are placed the theoretical percentages of the two sulphides alluded to:—

	Toluca.	Charcas.	Troilite (FeS).	Pyrrhotite (Fe_7S_8).
Iron	59·01	56·29	63·64	60·5
Nickel	0·14	3·10	...	...
Copper	trace	...	...	...
Sulphur	40·03	39·21	36·36	39·5
	99·18	98·60	100·00	100·00
Sp. gr.	4·799	4·780	4·784[1]	4·583[2]

From these results Meunier concludes that the meteoric sulphide has the formula of pyrrhotite—in short that it is not a monosulphide. It will be seen, however, in the foregoing table, that though the analytical numbers point to this conclusion, the specific gravity of the sulphides accords more closely with that of troilite. Analyses of the sulphide in the meteoric irons of Knoxville, Seeläsge, Sevier Co., and Ovifak (see page 123), show that sulphide in each case to have the composition Fe S. The author states that both sulphides are feebly attracted by the magnet. Though magnetic pyrites in fine powder is attracted, troilite (Fe S), neither in coarse fragments nor in powder, shows, according to my experience, the least tendency to adhere to the magnet.

The crust of the Toluca iron has the following composition:—

Iron sesquioxide = 68·93; Iron protoxide = 28·12; Nickel protoxide = 2·00; Cobalt protoxide = trace. Total = 99·05.

which numbers correspond to the formula $Fe_2 O_3$, (Fe Ni) O.

By treating the Charcas iron with mercury chloride a very small quantity of silicate (?) was obtained, which was not further examined. The particles resembled those obtained from the Caille iron in their action on polarized light. It will be remembered that in the Toluca iron G. Rose found a few grains of what he held to be quartz.

Meunier gives the results of an analysis of the meteoric iron found at Xiquipilco in 1784:—

Nickel iron	96·301
Troilite	1·482
Schreibersite	1·232
Graphite	1·176—100·191

The development of figures on polished surfaces of meteoric iron by exposing them to heat and the action of acids, fused alkalies, or saline solutions, has been studied by Meunier. When the Charcas iron is heated, there are simultaneously developed on different parts of the surface the varied colours exhibited successively on a plate of

[1] Mean of three determinations of the specific gravity of the meteoric sulphide.
[2] Mean of five determinations of the specific gravity of pyrrhotine.

steel by raising it to different temperatures. On examining the altered iron, the author was enabled to detect the presence of a small amount of the alloy termed plessite. The figures are in their general characters identical with those developed by acid. When a polished plate of the Charcas iron is plunged into a hot solution of copper sulphate, the figures are developed with greater distinctness than when acid is used, the lamellæ of tänite appearing red on a white ground. By employing mercury chloride and varying the degree of concentration and temperature of the solution, a metallic surface may be made to present as many as three different phases of crystalline development. With a hot concentrated solution of this salt the Charcas iron exhibits the most beautiful figures. Gold and platinum chloride have also been used by the author, and the former salt is recommended in cases where it is desired to arrive at an immediate knowledge of the crystalline structure of an iron.

To etch a fine section of Toluca iron, recently acquired by the British Museum, water saturated with bromine was used. The edge of the slab was surrounded with modelling wax; the bromine water was then poured on, and in a few seconds removed with blotting paper. The surface was next flooded with distilled water, which was removed as before. Absolute alcohol was then poured over the etched surface, and this again was quickly taken away with bibulous paper. The iron was then preserved face downwards for some days in a dry box filled with burnt lime. Plate IX. gives a representation of a part of the surface of this beautiful slab of metal. The figures will be considered when we come to describe those of the Braunau iron and the crystals of meteoric iron which occur in the Cranbourne meteorite.[1]

(To be continued in our next Number.)

VI.—Notes on the Specific Gravity of Precious Stones.

By Prof. A. H. Church, M.A.

FROM time to time I have accumulated a large number of results obtained in identifying precious stones by means of their specific gravity. From these results I have selected about 70, which will be found arranged below. The observations have been made with care, and, where no temperature is given, at 15° 5 C.; an asterisk denotes those determinations in which a very accurate assay balance by Oertling was used, and in which the specimens were immersed in alcohol, not in water. In these latter determinations any error would be confined to the third place of decimals.

No.	*Name.*	*Remarks.*	*Spec. Grav.*
1.	*Adularia	Moonstone, flawless, Ceylon	2·585
2.	Beryl	Brownish yellow, flawless	2·69
3.	,,	Deep sky-blue, flawless (probably been heated)	2·701
4.	,,	Yellow, became blue after ignition but unchanged in spec. grav.	2·697
5.	,,	Fine aquamarine, weighing 5·73 grams	2·702

[1] Kick (*Pol. Notizbl.* xxix. 105; *Pol. Jour.* ccxii. 40) employs for the etching of artificial iron and steel a mixture of one part of hydrochloric acid and one part of water, to which a little antimony chloride has been added. Surfaces etched with this liquid are less liable to rust. Kick states that some irons and steels are quite passive, but that this property may be destroyed by raising them to a red heat.

It will be seen from these determinations that the density of this species (beryl) is remarkably constant. I found very nearly 2·7 for a crystal of emerald of good colour, but the number would doubtless have been rather higher had there been no flaws in the specimen.

No.	*Name.*	*Remarks.*	*Spec. Grav.*
6.	CHRYSOBERYL.	Golden yellow, flawless...	3·84
7.	„	Brownish yellow, flawless	3·734
8. *	„	Yellowish brown, flawless	3·7
9. *	„	Emerald green, slightly flawed	3·86

The above numbers serve to show that chrysoberyl may be distinguished from chrysolite by its specific gravity, although the greater hardness of the former species is sufficiently decisive on this point. Jewellers constantly make a confusion between the two stones, especially in small specimens of a yellow hue; but the following determination of the specific gravity of a good chrysolite shows this stone to be less dense than the former:

10.	CHRYSOLITE.	Peridot of rich green colour, flawless...	3·389
11.	„	The same stone as No. 10, after ignition	3·378
12.	*GARNET ...	Essonite, nearly flawless	3·631
13.	„ ...	Essonite, flawed	3·604
14.	„ ...	Essonite, slight flaws	3·666
15.	„ ...	Essonite, a fine specimen	3·642
16.	„ ...	Dark red, flawed and opaque in parts...	4·058
17.	„ ...	The same stone after heating	4·044
18.	„ ...	Red, transparent	4·059
19.	„ ...	The same stone after fusion...	3·596
20.	„ ...	Clear red	3·89
21. *	„ ...	Very pale brownish red	3·682
22. *	„ ...	Rather darker than No. 21	3·696

Nos. 12 to 15 were specimens of the stone usually called by jewellers the jacinth. The above determinations are corroborated by a series of specific gravities of this stone communicated to me by Mr. Rudler. The deep red or precious garnet often has a specific gravity close to that of the ruby. Specimens of a fine variety of red garnet have been lately sold for the true ruby; indeed, one of these garnets, well cut and mounted with diamonds, requires a practised eye for the recognition of its real character.

23.	* QUARTZ. ...	Milky, banded, flawless ... ... 19°	2·642
24.	„	Amber yellow, flawless	2·647
25.	„	Pale brown, with whitish streaks	2·651
26.	„	Smoky, pale brown	2·66
27.	„	Pure rock crystal	2·65
28.	„	Pale yellowish brown, flawless	2·663
29.	„	Amethyst, very dark	2·662
30.	„	Amethyst, dark	2·658
31.	„	Amethyst, not so dark as Nos. 29 and 30	2·659

The above numbers seem to show that dark-coloured amethyst is really denser than pure crystal; while the latter, again, is denser than milky quartz.

32.	SAPPHIRE. ...	A white crystal, banded with blue	3·979
33.	„	Golden yellow, flawless	4·03
34.	„	Yellowish grey, subtranslucent	3·94

I believe the specific gravity of white, yellow, and blue sapphire is rather over 4 when the specimens examined are perfectly free from flaws.

No.	*Name.*	*Remarks.*		*Spec. Grav.*
35.	SPINEL.	Indigo coloured, flawless	16°	3·675
36.	,,	A similar specimen		3·715
37.	,,	Puce coloured, flawless		3·637
38. •	,,	Rose coloured, flawless		3·631

Red, pink, and pale spinels are, I have found, rather less dense than the deep blue and greenish blue stones. The specific gravity of this species is very close to that of the hyacinthine garnet.

39.	TOPAZ.	White, flawless, from Brazil		3·597
40.	,,	White, flawless		3·571
41.	,,	White, flawless		3·585
42.	,,	White, slightly flawed, from Brazil		3·564
43.	,,	White, flawless—weight 4·369 grams		3·572
44.	,,	White, flawless		3·595
45.	,,	White, flawless		3·597
46.	,,	Wine-yellow, flawless		3 539
47.	,,	The same crystal after ignition and change of colour to pink		3·533
48.	,,	Deep pink, flawless. Had been heated; weight —2·289 grams		3·534
49.	,,	Pale sky blue, flawless		3·541

The very brilliant white topazes from Brazil have (so far as my experiments have gone) a slightly higher specific gravity than the stones of less lustre from Flinders Island and other localities. Coloured topazes also, from all localities, appear to be less dense than those without colour. Heating, which changes the yellow colour of a topaz to a rose pink, effects no alteration in its density.

50. *	TOURMALINE.	Green, flawless, from Brazil	17°	3·154
51.	,,	Grass-green, flawed		2·89
52.	,,	Black, from Bovey Tracy		3·124
53.	,,	Black, Bovey Tracy		3·12
54.	,,	Dull greyish green, flawless		3·303
55.	,,	Green, very slightly flawed		3·109

Black tourmalines are occasionally miscalled garnets.

56.	ZIRCON.	Brownish yellow, transparent, flawless		4·679
57.	,,	Jacinth from Expailly, flawless (unaltered by ignition)		4·863
58.	,,	Greenish, from Ceylon, flawless		4·579
59.	,,	The same stone (58) after prolonged ignition		4·625
60.	,,	Yellow, flawless		4·6
61. *	,,	Brownish yellow, flawless		4·62
62.	,,	Brown, flawless		4·696
63.	,,	Dull dark green, slightly opalescent, flawless		4·02
64.	,,	Hair brown, transparent but flawed, Fredriksvärn		4·489
65.	,,	The same crystal, after prolonged ignition		4·633
66.	,,	Pale brown, opaque, Green River, Henderson Co., North Carolina		4·54
67.	,,	The same crystal, after prolonged ignition		4·667
68.	,,	Deep red, flawless, from Mudgee, New South Wales		4·705
69.	,,	The same stone, after prolonged ignition		4·7
70.	,,	Pale green, flawless, from Ceylon		4·691

The above numbers call for two remarks. Firstly, it will be seen that though the density of zircons from some localities is increased by ignition, this is not the case with the Expailly or Mudgee specimens, which remain unaltered by heat. Secondly, some zircons are of very low density (No. 63 above). This density remained the same after heating. The stone was a true zircon however, giving on analysis the per-centages of that species.

VII.—Glacial Erosion.[1]

By J. G. Goodchild, F.G.S.;
Of H. M. Geological Survey of England and Wales.

The Lower Carboniferous rocks of the Yorkshire Dale District—Wensleydale, Swaledale, Dentdale, Garsdale, and the adjoining parts—consist of a series of alternations of limestones, sandstones, and shales, not usually much inclined from horizontality. The harder beds of these commonly form terraced outcrops, which are often several hundred yards in width from the scar or the steep escarpment at their outer edge to their inner margin where the next bed above comes on. Owing to the nearly horizontal position of the rocks throughout the greater part of the district, many of these terraces and scars can be followed for miles almost without interruption. Hence they form perhaps the most prominent characteristics of the Dale District scenery, and they offer a striking contrast with the generally regular outline of the dome-shaped hills, and the short and irregular scars that characterize the adjoining area of Silurian rocks.

The principal object of the present communication is to endeavour to show how these Carboniferous terraces and scars were formed.

Whilst engaged with Professor Hughes upon the Geological Survey of the Dale District I often noticed that the swallow-holes marking the presence of the limestones there occur along only the inner margin of each terraced outcrop, while nearly all the rest of the rock exposed is entirely free from such indications of Subaerial Denudation. Then again, the inner and the outer margin of each rocky shelf are rudely parallel to each other and to the outlines of the terraces both above and below; and where the valley is not very wide, the outline of each scar, whether convex, nearly straight, or concave, is matched by the corresponding form in the scar formed by the same bed on the opposite side of the dale. Not less striking is the frequent absence of any debris from the higher beds on the same hill-side, even from those close above the limestone of the terrace.

Hitherto it appears to have been assumed that the long-continued action of subaerial agencies is sufficient to produce the phenomena here referred to; but, however plausible at first sight this theory may seem, when it is applied to explain some of the facts that an attentive examination brings to light, it fails completely.

[1] The substance of the following communication was laid before the Geological Society 24th June, 1874, by permission of the Director-General of the Geological Surveys. It is reproduced in its present form in order that the accompanying theories may evoke some criticism, which they could not receive when the original article, together with 26 others, was read in brief abstract at the last meeting of the Session.

Whatever theory is proposed to account for the present form of the rock surface in the Yorkshire Dale District must be based upon not only the various classes of facts that are now almost on all hands admitted to be the work of subaerial agencies, but also upon the following points that do not so easily admit of an explanation:—1. The outcrop of each limestone is weathered nearly equally all over; and as a rule swallow-holes are found only along its inner margin, although there is occasionally a width of several hundred yards between the inner margin where the swallow-holes are found and the scar that forms the outer edge of the terrace. 2. Between the tributary valleys the scars either extend in nearly straight lines or else sweep in broad convex or concave curves, whose general regularity is only occasionally interrupted by the channel of a small stream from the higher ground. 3. The scars are as often found perfect at elevations of several hundred feet above the bottom of the valley where they occur as are those lower down. In the case of the highest thick limestones of the Yoredale Rocks, known respectively as the Main and Undersett Limestones, the thinness of the intervening beds causes the outcropping scars of the limestones to run in pairs, which often keep the same horizontal distance apart for miles, and thereby render their regularity of form more than usually striking. 4. Where the rocks are much disturbed, the characteristic terraces usually keep to the same bed through all its variations of position and inclination; so that instances are not wanting in which the same bed forms a terrace rising two hundred, or even four hundred feet within half a mile. 5. Little disintegrated rock from the beds above is commonly found upon the limestone terraces, even where the absence of such debris cannot be accounted for by stream action. 6. And lastly, the terraces and scars developed along the outcrop of each limestone are usually even more perfect than those of the less-easily-weathered sandstones that they are associated with.

Bearing these points in mind, let us see how far the commonly received theories will apply in the present case.

As the terraces here referred to are seldom horizontal for any great distance, and sometimes have a slope of even several degrees, it is obvious that their marine origin is quite out of the question. This theory therefore will be passed without further mention.

The other great class of agents at work developing the surface characteristics of each rock is usually designated Subaerial Denudation. Under this term most writers include also the abrading work of ice; but in the present communication Subaerial Denudation will be taken to mean only that kind of alteration of the form of the ground that is effected by the separate or the combined action of the weather and running water; while the term Glacial Erosion will be used for the abrading work of moving ice. For the present we have to deal only with the effects of Subaerial Denudation upon the particular kinds of rock that make up the hills of the Dale District. Of these by far the most important rock is limestone, which is found interstratified with the other rocks in bands whose thicknesses range from a few inches to a hundred feet or more. In character most of it is of the ordinary Mountain Limestone type—a more or less compact, grey rock, occurring in "posts" from a few inches to several feet in thickness. Each bed of limestone is almost invariably overlain by more or less shale, and nearly as often it lies directly upon sandstone; so that the order of the beds from the top of the series to the lowest beds seen is, soft shale upon limestone, which, in its turn, lies upon a still harder bed of sandstone.

Under the action of the weather each kind of rock behaves differently. Where the outcrop is of shale, and forms a steep bank alongside a stream, the numerous divisional planes help to make the rock go to pieces in a very short time; so that, in such a case, whatever the overlying beds may be like, the bank is not long in being cut back. But where the outcrop forms a gentle slope that is out of the way of constantly running water, shale that is not more than usually sandy decomposes into a tough clay, much of which remains at the surface, and thereby greatly helps to lessen the waste of the beds beneath. Some good examples of the different rate of weathering of the same bed of shale where exposed to the action of running water, and where affected only by weathering, are found about the waterfalls or "fosses" in the Dale District. Under the waterfall the shales are kept in the condition most favourable for their rapid decomposition, so they are quickly cut back beneath the harder beds that form the edge of the fall. But at the outer end of the ravine that has been caused by the gradual recession of the waterfall, so little has subaerial denudation accomplished, notwithstanding that a rapidly flowing stream is at hand, that the difference between the rate of recession of the fall and that of the sides of the ravine is occasionally as 40 to 3. In other words, while the waterfall is cutting back forty feet each cliff it has left recedes only eighteen inches. The particular instance here referred to is doubtless an extreme case where the beds overlying the shale are more than usually durable; but it serves to prove that even where there is a rapid stream flowing the denudation of shale does not go on very rapidly unless the stream actually flows close to the outcrop. Where limestone is the rock that overlies the shale, this is usually cut back much faster, because the surface water finds an easy passage through the joints of the harder bed. It will be interesting to compare the figures given above with those obtained in similar instances elsewhere. In all such cases the difference between the width of the outer end of the ravine and the width close to the fall, compared with the distance between the two points thus measured, will give very nearly the ratio between the rate of denudation, on any given rock, by stream action, and that of ordinary weathering.

If then, so little denudation of a rock as easily worn as shale has been accomplished in Post-Glacial times by the rapid streams of the Dale District, where these streams are absent we ought to find the rate of denudation so slow as to produce results that are hardly perceptible. Accordingly, it is not uncommon to find glacial striæ within a few feet below the outcrop of a bed of shale; in which case the horizontal distance between the ice-markings and the base-line of the shale marks the greatest distance that this can have been cut back in Post-Glacial times.

The thinner kinds of sandstone, especially where they are much split up by beds of shale, seem to go to pieces very readily; but upon the more compact, blocky, and little jointed kinds ordinary weathering seems able to produce very little effect. A very good example of this is to be found at Mosedale Foss in Wensleydale—a waterfall caused by the superposition of a hard and blocky sandstone on a bed of soft and thinly laminated shale. The length of the ravine that the fall is found in is nearly eight hundred feet from its outer end to the fall itself; while the difference in the width of the ravine at the two points measured is only sixty feet. Yet in this instance a rapid stream flows within a few yards of the foot of the scars, which have thus receded only thirty feet on each side since the ravine was formed. There is good reason for thinking that this was in Post-Glacial times. The remarks made above relative to the nearness of glacial striæ to the outcrop of higher beds of shale apply equally to the accompanying sandstones in similar positions; thus we get direct evidence that some of the sandstone scars have not been much altered in form since the close of the Glacial Period.

For our present object the rock of most importance as regards its behaviour before subaerial agents is limestone. Not much more need be added to what has been already stated about the cutting back of a waterfall in this rock: where, however, it is found in thick beds, and is not very much split up by structural planes, limestone seems, under like conditions, to recede not quite as fast as sandstone. But under the influence of the weather, limestone, as is well known, often disappears with great rapidity. Jukes's comparison of it to a glacier melting before the summer's sun conveys an excellent idea of the way this rock is dissolved and carried away in solution by the waters from the surface. The numerous structural planes that every bed of limestone is more or less divided by are developed and rapidly widened to a considerable depth from the surface by the action of the acidulated waters, which thus easily find their way to a lower level. There seems reason for believing that the absolute rate of dissolution of limestone is far from slow, even when measured by years. In Kirkby Stephen Churchyard there was in 1871 an erect gravestone of ordinary mountain limestone that was put up about fifty years ago. As the stone was carved, at least the greater part of it must once have been smooth and unweathered; when I saw it in 1871 there were encrinite stems and bits of other fossils left in relief to the extent of a tenth of an inch or more, because the softer matrix had been removed by the rain that has fallen on the stone since its erection. One cannot be quite sure even that the highest parts of the fossils accurately represent the original dressed surface; but, assuming that they do so, we have in this instance proof that a smooth and quite unweathered piece of limestone, standing in a position the least favourable for erosion by subaerial agencies, is being dissolved away at the rate of one inch in five hundred years. Where the form of the surface is such that water can remain some time upon the rock, all the structural planes near the surface are rapidly widened, by which the removal of the rock is greatly facilitated.

It will then readily be admitted by most geologists that under purely atmospheric conditions the rock that tends to disappear the fastest is limestone; next to this shale; and the slowest of all to weather away is sandstone.

When subjected to mechanical erosion, as when these rocks are being worn in a river channel, the rates of abrasion are nearly as the relative hardnesses of the three kinds of rock. Shale goes fastest, next to this come the thinner-bedded sandstones, and longest of all in being worn away are the blocky sandstones and the purer kinds of limestone. The last-named rock especially seems able to withstand much of the ordinary wear and tear of even a large stream. In the case of some of the waterfalls, the limestone forming the floor of the ravine is rarely worn down many feet lower at the outer end than it is found beneath the fall. The same remark applies also to many of the harder beds of sandstone.

Thus far then it seems clear that the rocks that best withstand mechanical erosion are at the same time those that are least able to withstand Subaerial Denudation. Therefore, if Subaerial Denudation has really had so much to do with the development of the existing surface characteristics, we ought to find the more prominent features exclusively of sandstone; while the accompanying limestone, everywhere but near the streams, should be dissolved clean out of sight. But, although there are in the Dale rocks frequent alternations of limestones with sandstones and shales, in the majority of cases the more prominent terraces and scars consist solely of limestone.

If rivers have been concerned in the formation of the features in question, it is difficult to understand how these have retained their regular form in such perfection while the stream that produced them has cut down several hundred feet into the rocks beneath. It is not easy to believe that a river ever extended right across the dale from the highest scar on one side to the corresponding scar on the other; yet the advocates of the subaerial theory virtually assume that when the scars were formed the rainfall was so much greater than at present that the river filled the dale from side to side. There can be no better proof of the fallacy of this argument than is afforded by the existence of inclined scars that rise towards the lower end of the valley. A good instance is found near Carperby, in Wensleydale, where a limestone scar and terrace, after a rapid descent of nearly four hundred feet in just half a mile, rises again to the same level within twice that distance, in the direction of the mouth of the valley. Yet in this instance the scar and its accompanying terrace are as perfect at the highest point as at the lowest; and where the bed that forms the scar is faulted, scars of nearly the same character occur at different levels within a few yards of each other on the opposite sides of the dislocation. All such denudation by rivers is limited to the zone between the highest flood-line and the bed of the river—rocks also from points above this are it is true often undermined and brought down; but a terrace can be formed only within the vertical limits just named. Hence it is clearly impossible for a river to shape rock into a terrace that is inclined several degrees from the horizontal.

Thus far then the objection against the fluvial origin of these rock ledges are: 1st, Many of them are situated a thousand feet above where any stream that could give rise to them could possibly flow. 2nd, The scars on both sides of the valleys often maintain a rude parallelism for long distances; a convex outline on the one side being opposed to one correspondingly concave on the other, even where the distance across the valley between the two scars exceeds a mile. Lastly, each bed gives rise to a form of terrace that has some more or less marked peculiarity which appears at whatever inclination that particular bed may be lying at, and at whatever elevation it may occur above the bottom of the valley.

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

VIII.—The Erroneous Nomenclature of the Drift.

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

THE necessity for a reform in the present nomenclature of the Drift is apparent from the different papers on the subject, but more especially from the note appended to Mr. Bird's supplementary paper on the "Post-Pliocene Formations of the Isle of Man" (Geol. Mag. May, 1875, p. 228). The author of this paper states that this glacial drift is "generally marine." May I ask how a drift deposited in the sea can be called glacial? Undoubtedly, originally, it was ice-formed, but so also are all the drifts or the major portion of them, that at the present day are accumulating in the seas round our islands, in our lakes, and in our river valleys; let them be shingle, gravel, sand, silt, or a boulder drift. A normal glacial drift must be deposited direct from ice. If, however, subsequently it is sorted and re-arranged by water or any other agent, it ceases to be glacial. If any other definition of glacial drift is allowed, in glacial drift may be included shingle, gravel, sand, silt, besides the different boulder-clays, at the caprice of the explorer or writer, if he can only prove that subsequent to their being in their present condition, they had been normal glacial drift. At the present day, if the sea, the waters of a lake, a river, or even rain, is denuding glacial drift, a boulder-clay may be forming, identical in aspect, with these so-called "stratified glacial drifts"; they evidently are not glacial drifts, yet they are formed by similar secondary arrangements to those drifts that some observers would rank as glacial.

In all hilly ground (such as the Isle of Man), after the ice had retired and the sea occupied its place, the margin of the latter, rivers, etc., formed cliffs in the glacial drift, at the base of which, sands and such-like deposits accumulated; the latter, in many cases, were subsequently covered up by the weathering from the cliffs, the newer depositions being stratified boulder-clays, but of meteoric origin, and probably formed long after all the ice had left the country. Or the high-lands may have been enveloped in ice, and from the margins thereof, rock detritus may have been dropped into the sea, forming drift accumulations, not, however, normal glacial drift, as the detritus would have been more or less washed and re-arranged by marine action.

As to the Irish drift. Over twenty years ago, it was supposed that there were two glacial drifts separated by gravels and sands; but during the subsequent examination of the island under the late J. Beete Jukes, F.R.S., it was proved, that although there are two glacial drifts (boulder-clay drift and boulder or moraine drift), yet between them there are no sands and gravels, the sands and gravels being newer than both, and found indiscriminately on either. Within the last few years, however, on very partial and immature observations, this old theory of the "middle gravels" was again started; but in subsequent papers the unsoundness of the arguments and statements in its favour was demonstrated. If the author of the paper on the "Post-Pliocene Formation of the Isle of Man" will turn to my letter in the April Number of the MAGAZINE, he will find that inadvertently he misquotes it. A glacial drift *above* the "middle gravels" is what has not been found in Ireland, but an upper glacial drift is well known.

IX.—The Post-Pliocene Formations of the Isle of Man.

By John Horne, F.G.S.;
Of the Geological Survey of Scotland.

In the postscript to his paper on the Post-Pliocene Formations of the Isle of Man, Mr. J. A. Birds takes exception to my classification of the Manx drifts.[1] He states that, "*a priori*, is it not against Mr. Horne's view of his Lower Boulder-clay being really such that there should be intermediate formations of sand and gravel when the cold was at its extreme, and the ice, according to his showing, from 2000 to 3000 feet thick?" To those who are well acquainted with the appearances presented by interglacial deposits, this objection cannot have any weight. The Lower Boulder-clay or Till of North America, of Sweden, and of Scotland, contains well-marked accumulations of fossiliferous sedimentary matter; and non-fossiliferous sand and gravel are of common occurrence in the Till of these and other countries. From these and other considerations, it is most probable that the Till or Lower Boulder-clay and its intercalated beds betoken a succession of cold and warm periods. The appearance of layers of sand and gravel in the Manx Boulder-clay is quite in keeping with the facts referred to.

Mr. Birds further notes, "that if all the deposits are assigned to the first glacial period and the great submergence, what memorials are left, beyond some possible moraines, of the second glacial period, or the times next preceding and following it? Surely there ought to be such if the land has not been submerged since." The author seems to forget that the glaciers of the post-submergence period were confined mainly to the upland valleys. They did not deploy

[1] See Geol. Mag. May, 1875, p. 226.

far into the low grounds, and therefore no other memorials could have been left, except "some possible moraines."

One or two remarks may now be made on the succession advanced by Mr. Birds. He considers the true Lower Boulder-clay to be represented by the shelly clays which occur in the cliff sections in the north part of the island, stretching from Ramsey to the Point of Ayre, and thence to Kirkmichael. Forbes long ago examined these beds, and pointed out that they lie usually at the base of the cliffs, being capped by a great thickness of stratified sands and gravels, on which rest large boulders. Now the difference between these shelly clays and true Lower Boulder-clay is so distinct and obvious that I cannot see how any one who has had experience in mapping drifts can possibly confound them. The clays, which attain a great thickness between Sea-view and Port Cranstal, contain few stones. These are no doubt smoothed, and often scratched; but their occurrence is quite exceptional. Moreover, the clays are often finely laminated, and the position of the stones in some places is such as to lead one to believe that they had been dropped during the accumulation of the thin layers of mud. In short, these marls, so far as I saw, strongly resemble in general appearance the glacial clays of the Forth and Clyde basins, and similar deposits at Dumfries in the Nith basin. It is hardly necessary to point out that such is *not* the character of true Lower Boulder-clay or Till. This latter deposit is always highly charged with stones, most of which are scratched on every side, the matrix being extremely tough and quite devoid of stratification. But further, these marls, north of Ramsey, contain shells in abundance, which have been named by Forbes; while the true Lower Boulder-clay is unfossiliferous. It is quite true that shells have been obtained from Boulder-clays in different parts of Scotland, Lancashire, and elsewhere; but these are more recent than the Till, though belonging to the pre-subergence period. If further proof were needed to convince Mr. Birds that there is a difference between these shelly clays and true Boulder-clay, reference might be made to a section near Port St. Mary, on the south side of the island. After turning the point south of the lime-kilns, a deposit of stiff stony clay, packed with angular, subangular, and smoothed stones, most of them scratched, is found resting on striated beds of Carboniferous Limestone. This bed, which resembles an Upper Boulder-clay, is overlaid by finely laminated Brick-clay with shells, but containing few stones, from 8 ft. to 10 ft. thick; while the shelly clay is capped in turn by stratified Sands and Gravels. There can be little doubt that this shelly clay is of the same age as the marls north of Ramsey, and, if so, then there is here direct evidence that the shelly clays are more recent than the Upper Boulder-clay.

Again, Mr. Birds ranks all the Boulder-clays, other than the shelly clays, as belonging to his upper series. "This Upper Boulder-clay," says the author, "was not formed altogether during the second continental period, but probably it was deposited during the middle or towards the latter end of the emergence, and continued to be deposited for some time during the second submergence."[1]

[1] See Geol. Mag. Feb. 1875, p. 82, *et seq.*

His diagrams, which are intended to illustrate this statement, show that he believes his Upper Boulder-clay to be POSTERIOR to the "Middle Drift" or Kame series. What are the reasons assigned by the author for slumping these Boulder-clays as part and parcel of his upper series? Because "this clay is found almost always at a higher level than the Middle Drift Sands, and from its containing scarcely any but local rocks, and those always angular or in a very slightly rolled condition, I conclude that it is the wash of the mountains towards the later part of their rise and in the beginning of their second submergence in the sea, and due partly to the action of the sea itself by tides and waves, partly to rainfall and an accumulation of snow and ice upon the land, combined with the most effective cause of all—the grinding of coast-ice swept along by violent currents." In the absence of any direct evidence of superposition, I fear that these arguments can have but little weight. In Scotland, for instance, true LOWER Boulder-clay occurs very frequently at higher levels than the Kame series; and in the Till there always is a preponderance of local over foreign rocks, the number of the latter diminishing in proportion to the distance from the parent source. As to the last of these reasons, my observations enable me to state that such is NOT the case with reference to all the Boulder-clays included in his upper series.[1] In the case of those Boulder-clays described in my paper as representing true Till, the stones are neither angular nor slightly rolled; on the contrary, they have the smoothed character of ordinary Till stones with well-marked scratches. Mr. Birds indicates localities unvisited by me, and, of course, I have nothing to say with reference to these sections.

The author further says: "As to which is the true order of the formations, the question must be determined, of course, by reference to sections, such as that of which Mr. Horne has given a lithograph, near the mouth of the Ballure Glen, and by all sections thence along the northern base of the hills to Kirkmichael." Glancing for a moment at this section exposed on the coast cliff, we have here two Boulder-clays, regarded by Mr. Birds as belonging to his upper series, which are separated by sands and gravels and capped by stratified sands and gravels, which appear to stretch northwards to Ramsay, where the "Middle Drift" series begins. This section seems to indicate that these Boulder-clays pass UNDERNEATH the stratified sands and gravels of the "Middle Drift" series. Other sections might be adduced which seem to point to the same conclusion.

NOTICES OF MEMOIRS.

RED CHALK AND RED CLAY. By PROFESSOR A. H. CHURCH. From the "Chemical News," May 7, 1875.

SOME years ago I published an analysis[2] of the Red Chalk of Hunstanton, Norfolk. The specimens which I examined more minutely were those in which the red colour, so characteristic of this variety of chalk, was exceptionally developed. In these speci-

[1] See Trans. Geol. Soc. Edin. vol. ii. part iii.
[2] 1863. Journ. Chem. Soc. (2), vol. i. p. 99.

mens I found a high per-centage of ferric oxide, with very little silica and alumina. Mr. R. C. Clapham had shown,[1] however, that some samples, at all events, of red chalk contained as much as 9·28 per cent. of silica, with 9·6 per cent. of ferric oxide and 1·42 per cent. of alumina, and that these three ingredients were also present in white chalk, though in much smaller proportions.

In view of the recent discoveries as to the materials constituting the floor of the deep sea, and acting upon a suggestion made by Professor J. Morris as to the probability of some near connexion between red chalk and the "red clay" of certain deep tracts of the ocean bottom, I have again studied the chemical nature of the former material; but this time I employed a different method of analysis, and I operated upon the paler and more ordinary variety of red chalk. The samples used were numerous, but the results of the treatment to which they were submitted were nearly uniform.

The following is a brief outline of the plan which was pursued in order to see if it were possible to separate from red chalk a red clay, slime, or ooze, similar to that which is reported by the officers of the *Challenger* Expedition to cover the Atlantic bed at average depths of some 2700 fathoms. Treatment with very dilute hydrochloric acid in the cold seemed the best way of removing the calcium carbonate present. This acid was allowed to act upon small crushed pieces of selected red chalk until fresh acid failed to remove any further traces of calcium. By appropriate washing in an apparatus similar to that figured in my "Laboratory Guide,"[2] the finer portion of the undissolved residue from the chalk was readily separated from the siliceous fragments which accompanied it. This finer portion remains suspended for some time when stirred up in pure water, and was found to be almost, if not quite, homogeneous; it contained no lime. It amounted, on the average, when air-dried, to 9·3 per cent. of the weight of the chalk taken, but some dark samples furnished higher per-centages. Its physical characters correspond, so far as I can learn, to those of the red residue obtained by Mr. Buchanan from the Globigerina ooze, and to those of the smooth red clay before referred to as brought up from the deeper parts of the sea-bottom.

The following analysis abundantly proves how closely the chemical composition of the red argillaceous residue from red chalk resembles the red clay in question:—

Analysis of Red Clay from Red Chalk.

	In 100 Parts.		
	Air-Dried.	Dried at 100° C.	Ignited.
Water	14·73	7·54	—
Silica	52·87	57·33	62·01
Ferric oxide (Fe_2O_3)	12·81	13·89	15·02
Alumina	15·65	16·97	18·36
Magnesia (MgO)	2·65	2·87	3·11
Potash (K_2O)	1·33	1·45	1·56
	100·04	100·05	100·06

[1] 1862. Chemical News, vol. vi. p. 313.
[2] "Laboratory Guide," 3rd edition, 1874, p. 163.

Although the above numbers clearly indicate a substance which may be fairly designated "a silicate of red oxide of iron and alumina," like the "red clay" of Professor Wyville Thomson,[1] it would be idle now to speculate as to the probable correspondence, in the minuter details of their composition, of the red chalk residue with the red clay of the deep Atlantic and Southern Sea. Still it may be profitable to allude to two or three points which are likely to throw light upon the relationship of the white, grey, and red chalk with the globigerina, the grey and the red ooze, respectively. First, analysis seems to show that the removal, in different degrees, of calcareous matter, however effected, has been the main cause of the differences of such formations. Secondly, it would appear that, although manganese dioxide is present in granules and nodules in the red oceanic clay and in the coarser particles of the red chalk, it is absent alike from the finely-divided substance of the former and the similar red residual slime of the latter. And, thirdly, the suggested relation beetween both these red matters and the mineral known as *glauconite* receives an unexpected light through the detection of sensible quantities of magnesia and potash in the red chalk residue; for the latter base is an invariable constituent, and the former an usual one of this species.

The complex and rather variable silicate which, from its grey-green hue, has received the name of glauconite, is known both in ancient and recent formations of greensand. The casts of animal forms which constitute the glauconitic grains of Cretaceous Greensand strata are paralleled by similar remains in the recent greensands of the Australian seas, and of those of the Agulhas current investigated by the scientific staff of H.M.S. *Challenger*. But the problem of the formation of recent greensand, or rather of glauconitic matter, at moderate depths, and of the related red clay at very great depths, is not yet solved. It is by no means necessary to suppose that glauconite was always first formed, and that it yielded the red clay in question by oxidation and partial solution, just in the same way that kaolin or white clay has been produced from felspar. This has probably happened in some instances; but it may be assumed, on the other hand, that the same constituents have yielded one or other of these two products, in accordance with differences in the dissolved gases and salts of the ocean and in the nature of its prevalent animal and vegetable forms.

One step towards the discovery of an answer to the problem now under discussion might be furnished by a careful study of the action, under pressure, of water holding oxygen and carbon dioxide in solution, upon powdered glauconite. But we really stand in need of more information as to this species itself, for the composition of the numerous minerals included under this name is somewhat ill-defined. Still we may conclude that it contains, as essential constituents, silica to the extent of 50 per cent.; a variable amount of alumina; much iron in the ferrous, as well as in the ferric condition; several per cents of potash; a little magnesia; and, finally, about

[1] Proc. Roy. Soc., vol. xxiii. pp. 39 and 45.

7 or 8 per cent. of water. It would not require a very profound alteration of such a mineral to give it the composition indicated by the analysis of our red chalk residue when dried at 100° C. Such alteration would involve peroxidation of the iron, removal of most of the potash, and relative increase of the alumina, results commonly seen in many altered mineral residues.

Great interest attaches to all questions concerning the red oceanic clay. Its minute analysis will, doubtless, solve some of the problems referred to in the present imperfect note. In the mean time, I am anxious that it should not be supposed that I ignore the differences which must subsist between recent oceanic deposits and the rocks which we may consider to have originated in former ages from similar materials. It is not that the mere process of consolidation must have altered them, but that the influences to which they have been subsequently exposed may have caused unsuspected, though not inconsiderable, changes in their chemical constitution. Materials for the discussion of this question are still deficient, and we must await complete quantitative analyses of recent glauconite, and of the red oceanic clay, before a decision can be reached. On account of this insufficiency of data, I have refrained from suggesting any formula for the red chalk residue, though it may have, like kaolinite, a claim to be regarded as a mineral species.

REPORTS AND PROCEEDINGS.

Geological Society of London.—May 12th, 1875.—John Evans, Esq., V.P.R.S., President, in the Chair.—The following communications were read:—

1. "Notes on the Occurrence of *Eozoon canadense* at Côte St. Pierre." By Principal Dawson, LL.D., F.R.S., F.G.S.

The author commenced by describing the arrangement and nature of the deposits containing *Eozoon* at the original locality of Côte St. Pierre on the Ottawa River. The Eozoal limestone is a thick band between the two great belts of gneiss which here form the upper beds of the Lower Laurentian. *Eozoon* is abundant only in one bed about 4 feet thick; but occasional specimens and fragments occur throughout the band. The limestone contains bands and concretions of serpentine, and is traversed by veins of chrysotile; the former an original part of the deposit, the latter evidently of subsequent formation. A thin section, 5½ inches in depth, showed:—1. Limestone with crystals of dolomite and fragments of *Eozoon*; 2. Fine-grained limestone, with granules of serpentine, casts of chamberlets of *Eozoon* and of small Foraminifera; 3. Limestone with dolomite, and containing a thin layer of serpentine; 4. Limestone and dolomite with grains of serpentine and fragments of supplemental skeleton of *Eozoon*; 5. Crystallized dolomite, with a few fragments of *Eozoon* in the state of calcite; 6. Limestone containing serpentine, as No. 2. The author criticized some of the figures and statements put forward by Messrs. King and Rowney, and noticed two forms of *Eozoon*, which he proposed to regard as varieties, under the names of *minor* and *acervulina.* He stated that fragments of *Eozoon,* included in dolomitic limestones, have their canals filled with transparent dolomite, and sometimes in part with calcite. In one specimen a portion was entirely replaced by serpentine. The author called particular attention to the occurrence of serpentinous casts of chamberlets, single or arranged in groups, which resemble in form those of the Globigerine Foraminifera. These may belong either to separate organisms, or to the Acervuline layer of the *Eozoon* ; the author proposes to call them *Archæospherinæ,* and describes them as having the form and mode of aggregation of *Globigerina,* with the proper wall of *Eozoon.* The author discussed the extant theories as to the nature of *Eozoon,* and maintained that only that of the infiltration of the cavities of Foraminiferal structure with serpentine is admissible. He particularly referred to the resemblance of weathered masses of *Eozoon* to Stromatoporoid Corals.

2. "Remarks upon Mr. Mallet's Theory of Volcanic Energy." By the Rev. O. Fisher, M.A., F.G.S.

Mr. Mallet's paper, read before the Royal Society in 1872, was discussed by the author *seriatim* as far as it seemed open to criticism. With respect to the condition of the earth's interior, whether it be rigid or not, Sir W. Thomson's arguments for rigidity were referred to, and geological difficulties in accepting his conclusions suggested. Mr. Mallet's views regarding the formation of oceanic and continental areas, that they have on the whole occupied nearly the same positions on the globe at all periods from the very first, were excepted to on the ground that all continental areas with which we are acquainted are formed of water-deposited rocks, and that therefore those areas must at some time have been sea-bottoms ; and if these wide features have not occupied the same positions which they now do from the very first, Mr. Mallet's explanation fails, that they were caused by unequal contraction when the crust was first permanently formed and thin. It was also shown that the theory of unequal *radial* contraction cannot account for the difference of elevation between continental and oceanic areas upon reasonable assumptions. For if we consider the crust to have been 400 miles thick (which cannot be considered *thin*), and to have cooled from 4000° F. to zero (a most extravagant supposition), then, if the crust had contracted one-tenth more beneath the oceanic area than it had done beneath the continental, we should only get a depression of one mile for the oceanic area, using Mr. Mallet's mean coefficient of contraction.

The main feature of Mr. Mallet's theory was then discussed, viz. that "the heat, from which terrestrial volcanic energy is at present derived, is produced locally within the solid shell of our globe, by transformation of the mechanical work of compression or crushing of portions of that shell, which compressions and crushings are themselves produced by the more rapid contraction by cooling of the hotter material of the nucleus beneath that shell, and the consequent more or less free descent of the shell by gravitation, the vertical work of which is resolved into tangential pressures and motion within the shell." Mr. Mallet's mode of estimating the amount of heat derivable from crushing a cubic foot of rock was explained, and it was accepted as a postulate, that the heat developed by crushing one cubic foot of rock would be sufficient to fuse 0·108 of a cubic foot of rock; or, in other words, that it would require nearly the heat developable by crushing ten volumes to fuse one. Mr. Mallet considers that the heat so developed may be localized. But Mr. Fisher inquires why, since the work is distributed equally with the crushing, the heat should not be so also; and since no cause can be assigned why one portion of the crushed portion of rock should be heated more than the rest, assumes that all which is crushed must be heated equally. In short, he is of opinion that if Mr. Mallet's theory were true, the cubes experimented upon ought to have been themselves fused.

After paying a just tribute of admiration to Mr. Mallet's elaborate and highly important experiments upon the fusion and subsequent contraction of slags, the author remarked upon Mr. Mallet's estimate of the probable contraction from cooling of the earth's dimensions, showing that it had been based on untenable assumptions. (The author of the paper, however, holds that the contraction of the dimensions of the globe has been greater than *mere* cooling will account for.) Upon the concluding portions of Mr. Mallet's paper, in which he estimates that the amount of energy afforded by the crushing of the solid crust would be sufficient to account for terrestrial vulcanicity, some strictures were made; but it was held that, if the main proposition had not been proved, these calculations were not of essential importance.

The Meeting was made special for the election of a Member of Council and of a Vice-President in the room of the late Sir Charles Lyell, Bart. W. Carruthers, Esq., F.R.S., F.G.S., was elected a Member of Council, and Sir P. de M. Grey-Egerton, Bart., M.P., F.R.S., F.G.S., a Vice-President of the Society.

CORRESPONDENCE.

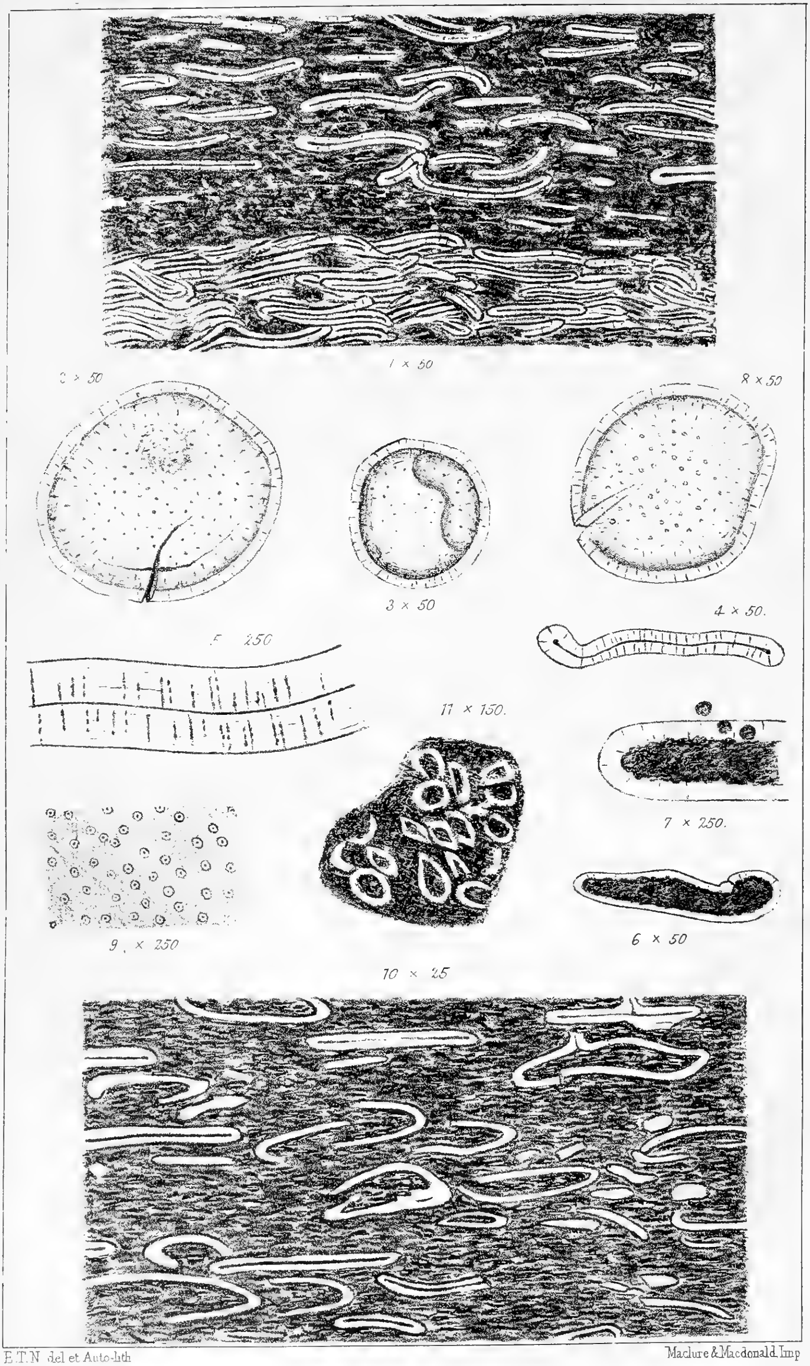
DENUDATION OF THE WEALD.

Sir,—I regret much that the gallant author of "Rain and Rivers" should think I had robbed him of one of his numerous honours; but at the same time I cannot feel that I am guilty. Messrs. Foster and Topley are not referred to as the authors of the Subaerial Theory of the Denudation of the Weald Valley, but as the authors of a memoir containing the information I required. Moreover, it would appear superfluous to mention Col. Greenwood's name, as the few readers I may have, must be fully acquainted with "Rain and Rivers." I appear to have been unfortunate in my selection, as the Denudation of the Weald seems to be an apple of discord, the gallant Colonel being the third claimant who has called me to task for having mentioned Messrs. Foster's and Topley's names.

The Author of "Valleys and their Relations to Faults," etc.[1]

Wexford, *June 4th*, 1875.

[1] London, 1875, Trübner and Co., 8vo. pp. 240.



E.T.N. del et Auto-lith. Maclure & Macdonald. Imp.

TASMANITES & BETTER-BED COAL.

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

No. VIII.—AUGUST, 1875.

ORIGINAL ARTICLES.

I.—On "Tasmanite" and Australian "White Coal."

By E. T. Newton, F.G.S.,
Assistant Naturalist, H.M. Geological Survey.

(PLATE X.)

THE two substances known as "Tasmanite" and Australian "White Coal," which are the subject of the present communication, have a special interest for the geologist on account of the light which they throw upon the microscopic structure and composition of many Coals. My attention was first directed to them when collecting materials for Professor Huxley's examination into the microscopic structure of Coal. My esteemed colleague, Mr. Etheridge, at that time gave me a specimen of brown laminated substance, labelled "Lignite, the so-called White Coal, Australia," and drew my attention to the fact that it was very largely composed of small seed-like bodies, very similar to, although smaller than, the macrospores[1] of *Flemingites*, which are to be seen in many kinds of British Coal. A specimen of this same kind of White Coal is in the Museum of Practical Geology, and is labelled, "Bituminous Shale (locally called White Coal), New South Wales, Australia." I have likewise been able to examine the specimen of Tasmanite also in this Museum, which is labelled "Tasmanite; combustible matter from the river Mersey on the north side of Tasmania; stratum of unknown thickness, but known to extend for some miles. Presented by Sir Wm. Denison." These specimens are very similar in appearance and structure, but the White Coal is softer than the Tasmanite. Chemical analyses of Tasmanite have been published, but I am not aware of any satisfactory account of its microscopic structure. The only mention of Australian White Coal with which I am acquainted is that in Prof. Huxley's lecture on "On the Formation of Coal" ("Contemporary Review," Nov. 1870). And there is a figure, of a section and some separated spores, given by Sir C Lyell in the 2nd edition of his Student's Elements of Geology, 1874.

The general appearance of the combustible schist, which is now generally known as Tasmanite, is thus described by Mr. J. Milligan,

[1] The bodies existing in Coals which have usually been termed *Sporangia* and *Spores* have been shown by Prof. Williamson to be *Macrospores* and *Microspores*. I believe both Professor Huxley and Mr. Carruthers are prepared to accept this determination.

in the earliest account of this substance which I have yet seen (Report of the Royal Society of Van Dieman's Land, 1852, p. 96): "There is on the right bank of the river [Mersey,] . . . . a series of beds of a brown schist,[1] of a nature highly combustible; its surface is usually finely punctated—it is semi-soft, sectile, fissile, flexible, and slightly elastic, and when held to a candle burns with a strong yellowish-white flame." When the substance thus described is examined with a pocket lens it is seen to be very largely composed of minute discs of a brownish colour, giving to the schist a granular aspect; this is probably the appearance alluded to in the above extract as "finely punctated."

The chemical analyses of Tasmanite made by Prof. Penny (Proceedings of the Royal Society of Van Dieman's Land, vol. iii. 1855, p. 108) and by Prof. Church (Philosophical Magazine, vol. xviii. 1864, p. 465) show that the discs are composed of a kind of resinous material, and that they are imbedded in a matrix of siliceous sand and clay.

It is perhaps worthy of remark that Prof. Penny puts the resinous matter at 26·24 per cent., and pyrites at 2·16 per cent.; while Prof. Church says the resinous matter forms 30 to 40 per cent. of the schist, and makes no mention of pyrites; he states however that the resinous matter contains a very large proportion of sulphur in chemical combination.

It appears from the observations of these two authors that the so-called resinous portion of Tasmanite is not really resinous, for it is insoluble in alcohol, ether, bisulphide of carbon, benzole, turpentine, and paraffin oil. Now the so-called bituminous portions of coal differ from resins in very much the same particulars; and when we find also that Tasmanite "affords a notable quantity of gas, which is similar in quality and powers to that obtained from cannel coal," although less in quantity, we must, I think, consider Tasmanite and Coal to be allied substances.

The large proportion of sulphur, which Prof. Church has shown to be in chemical combination in Tasmanite, is paralleled in the case of certain coals mentioned by Dr. Percy (Fuel, 1875), as being remarkable for the same peculiarity.

By the kindness of Mr. W. J. Ward, I am enabled to give the following particulars regarding the composition of Australian "White Coal":

Combustible Materials ..	29·58
Ash	68·47
Water	1·95
	100·00

After treating this *White Coal*, in a finely divided condition, with hydrochloric and hydrofluoric acids, and separating a small proportion of whitish sand by decanting, there was about 43·61 per cent. of residue, chiefly composed of the discs, but evidently still containing a small proportion of sand or clay, which had not been dissolved by the acids.

[1] Allied to Dysodile.

A portion of the discs carefully separated by sifting and again treated with hydrofluoric acid gave

Combustible material... ...	96·63
Ash (bright red)	3·37
	100·00

In order to ascertain the true nature of the *discs*, in either Tasmanite or White Coal, it is necessary to prepare thin slices of the schist for microscopic examination, and also, for the same purpose, to separate the discs by treatment with hydrochloric or nitric acid.

When the separated discs are viewed by reflected light, they appear as more or less circular bodies, somewhat thickened towards the circumference, many of them having their surfaces raised into irregular folds. If mounted in Canada Balsam, and viewed by transmitted light, many have the appearance represented in Pl. X. Figs. 2, 3, 8, while others exhibit the folds to which allusion has just been made. The more perfect discs are seen to be surrounded by a double contour-line—the optical expression of the fact that these discs are really thick-walled sacs. The saccular character, however, is best seen in transverse sections (Figs. 1, 4, 5), or when the sac is broken (Fig. 8). A closer examination enables one to see that the walls of these sacs are not homogeneous. A view such as Fig. 8 shows numerous dots scattered over the surface, which become somewhat elongated towards the edges of the disc. When examined with a power of about 250 diameters, the dots can be resolved into minute circles about $\frac{1}{3000}$ of an inch in diameter with a still smaller dot in the centre, as shown in Fig. 9. These structures are best seen in the discs of White Coal. It may be thought that these dots are comparable to the granules to be seen upon the surface of some of the macrospores of *Flemingites*; but the study of transverse sections shows at once that these dots are not mere surface-markings, for they can be distinctly traced as minute lines (tubes ?) passing from the outer to the inner surface. These lines are shown in Fig. 5, but owing to the section not being quite in the same plane as the lines, they do not appear to extend quite through. In addition to the fine lines, the walls of the sacs exhibit obscure longitudinal markings, which give them a laminated appearance (Fig. 5).

Neither Mr. Carruthers (Geol. Mag. 1865, p. 432), nor Mr. MacNaughton (Trans. Roy. Soc. Van Dieman's Land, vol. ii. 1855, p. 116), mentions any structure in the walls of these sacs.

The discs vary in diameter, as stated by both these authors, from about $\frac{1}{80}$ to $\frac{1}{50}$ of an inch. Mr. MacNaughton speaks of a thin outer coat to these discs, which may be seen when they are ruptured. I have examined all my preparations, both sections and separated discs, in order to distinguish this outer coat, but have been unable to do so. One easily recognizes in transverse sections, such as Fig. 1, that the walls of the sacs vary much as regards thickness; and among the separated sacs which are mounted in Balsam some may be seen much more transparent than the rest; but I have failed to see any real difference between the thicker and the thinner sacs, or to find them in anything like the relation of an inner and outer coat.

Nearly all the sacs are so compressed that their walls are brought into contact; but occasionally one may be found similar to Fig. 6, containing a quantity of black material differing in appearance from the surrounding matrix, and which appears to consist of minute rounded particles, about $\frac{1}{3000}$ of an inch in diameter.

With regard to the affinities of the discs, or rather sacs, it must be acknowledged that their true nature has yet to be determined. Their general structure seems to indicate that they are the spores or sporangia of some Lycopodiaceous plant; but their true affinities must remain obscure until they are found in their natural relation to the parent plant, or some recent form is discovered with which they can be compared. By the kindly help of Mr. Carruthers, I have been enabled to examine the fructification of several recent forms, but have failed to find anything comparable in structure to these sacs. Prof. Balfour, I believe, considers the Tasmanite discs to be closely allied to *Flemingites*; they differ from them, however, as Mr. Carruthers has pointed out (Geol. Mag. 1865), both in structure and size. All the *Flemingites* macrospores which I have seen have homogeneous walls, and in many of them is seen the triradiate marking, which is so generally present in cryptogamic spores (Prof. Williamson, Macmillan's Mag. March, 1874, p. 409). In none of the Tasmanite sacs have I been able to see this triradiate marking, although their structures are so clearly shown that these markings could not fail to be seen if they were present; and the walls, as we have already seen, have a definite structure. The sporangia of *Lepidostrobus* figured by Dr. Hooker (Mem. Geol. Survey, 1848, vol. ii. part ii. pl. 6, figs. 4, 10, and pl. 7, fig. 7) have somewhat the same appearance as the transverse sections of Tasmanite sacs, that is to say, they show a series of lines perpendicular to the surface. A closer examination, however, of the figure, or, still better, of the original specimens, shows that the two structures are not the same. In the *Lepidostrobus* sporangia the lines are really the walls of the cells of which the sporangia are composed. In the Tasmanite sacs the lines have quite a different appearance, and a surface view shows that they are not merely the lines of junction between cells.

The minute black bodies mentioned above as filling the cavities of some of the discs are very much smaller than any of the microspores mentioned by Prof. Williamson (Macmillan's Mag. March, 1874, p. 408), and they do not show any cell wall.

In the abstract of a paper by Mr. Thos. S. Ralph (Trans. Roy. Soc. Victoria, vol. vi. 1865, p. 7), the discs of Tasmanite are referred to Algæ. This, I venture to think, is improbable.

There can be no question as to the *Tasmanite* sacs being vegetable organs, although at present we do not know the plant to which they belong. Their size and form seem to indicate that they are more nearly allied to Lycopodiaceous macrospores than to anything else.

The inconvenience of having an object without a distinctive name induces me to propose one for the spores (?) found in Tasmanite and Australian White Coal (the two being, as I believe, identical in structure); and in order to retain existing titles as far as possible, I would suggest that Prof. Church's name *Tasmanite*, which is so generally used in reference to the schist as a whole, be retained for this substance, and that the spores (or rather the plant to which they belong) should be called *Tasmanites*, with the specific title of *punctatus*, in allusion to their surface-markings.

The piece of *Tasmanite* drawn in Figure 1 was chosen on account of its exhibiting portions in which the spores are unusually far apart, and others where they are more numerous and compressed. It is this compressed portion which so closely resembles the structures seen in many coals, and which Prof. Huxley believes to be masses of spores and sporangia (Contemporary Review, Nov. 1870). Improbable as it may seem to some persons that the combustible portions of a bed of coal several feet in thickness should be for the most part composed of spores, yet such is undoubtedly the fact in the case of Tasmanite and Australian White Coal. In both these substances the combustible portion consists entirely of sacs (*spores* ?), no other vegetable matter whatsoever being traceable.

If a section of Better Bed Coal, such as that mentioned by Prof. Huxley, be compared with one of Tasmanite or Australian White Coal (see Figures 1 and 10), the similarity of their structures will be at once apparent. The chief difference between them being, that while in the two last there are only large spores and the spaces between these are filled with sandy matters, in the former the interspaces between the larger spores are filled in with multitudes of minute spores mixed with mineral charcoal.

With regard to the mode of occurrence of Tasmanite, Mr. Milligan, in addition to the extract given above (page 338), says: "The same brown combustible schist [Tasmanite] presents itself a mile higher up the river, and on the same side, but at an elevation of more than 100 feet above the water, and then it appeared to dip slightly into a high and rather steep hill, etc.

"The brown combustible schist exhibits at the elevation last mentioned a thickness of six to seven feet in one distinct seam, passing upwards into laminated clay rock of a yellowish colour, interstratified with thin layers of the schist.

"Below the six-feet seam there is, for a space, the same alternations as above, but uninterrupted beds of compact yellowish and bluish white clays succeed, etc.

"The occurrence of thick beds of fine clay and clay schists without organic remains above the fossiliferous masses [rocks previously mentioned as occurring below the brown schists and clays], denote a tranquil condition of superstant waters, compatible only with the character of a capacious and sheltered bay, or deep and extensive lake; to which supposition the subsequent deposit of repeated layers of a highly combustible schist of undoubted vegetable origin lends great probability.

"An extended and close examination of these beds, and the formations with which they are associated, and a careful comparison of their fossil contents, will be required thoroughly to establish their ages in relation to each other, and to geological changes and epochs generally."

The changes in the physical condition of the land necessary for deposition of several alternations of beds of clays and schists, some of which are of considerable thickness, and the subsequent elevation of the whole to 100 feet above the level of the river, show that these Tasmanite schists cannot be of very recent origin, although the distinct and unaltered appearance of the spores might have led one to suppose that they were. The alternations of layers of the schist with beds of laminated clay rock, and the presence of masses of fossiliferous rocks below this series, are extremely suggestive, on account of their resemblance to the succession of strata in the Carboniferous Epoch; indeed, it seems highly probable, from Mr. Milligan's observations, that these beds of Tasmanite were deposited under conditions very similar to those under which Coal is now generally considered to have been deposited.

I have at present been unable to ascertain under what conditions the Australian White Coal occurs; its great resemblance to Tasmanite renders it highly probable that it occurs under very similar conditions.

The foregoing consideration regarding the composition, microscopic structure, and mode of occurrence of Tasmanite, must, I think, lead to the conclusion, that this deposit is a bed of coal in process of formation; very inferior coal no doubt, on account of the large admixture of sand and clay, but nevertheless of such a character that it would be considered a true coal. The study of Tasmanite will, I think, enable us better to understand the appearances presented by certain coals: and certainly not the least important fact to be noticed is, that the combustible portion of this deposit, which is closely allied to coal, several feet in thickness and miles in extent, is formed entirely of spores.

EXPLANATION OF PLATE X.

Fig. 1.—Section of Tasmanite, cut perpendicular to the plane of bedding, × 50 diameters. In the upper two-thirds of the figure the spores are further apart than is usually the case; in the lower third they are very numerous and more compressed.

Fig. 2.—A large spore of *Tasmanites punctatus* which has been ruptured, × 50 diameters: showing the double contour and dotted surface.

Fig. 3.—A similar but smaller spore, with air in the interior; × 50 diameters.

Fig. 4.—Transverse section of a spore, the walls of which have been pressed together from the same section as Fig. 1; × 50 diameters.

Fig. 5.—Portion of Fig. 4, × 250 diameters, to show the perpendicular lines and laminated structure.

Fig. 6.—Spore filled with black material × 50 diameters.

Fig. 7.—Portion of similar spore × 250 diameters, shows three of the minute rounded bodies separated from the mass.

Fig. 8.—Spore of *T. punctatus*, from the Australian White Coal, × 50 diameters.

Fig. 9.—Portion of Fig. 8, × 250 diameters, to show the dots and extremely fine granulation of the intermediate portions of the surface.

Fig. 10.—Section of Better Bed Coal, cut perpendicular to the bedding, × 25 diameters. The large sac-like bodies are macrospores (*Flemingites*); the intermediate granular-looking portion is composed of microspores and a black material, probably mineral charcoal.

Fig. 11.—Section of same coal cut in the plane of the bedding, × 150 diameters. Small portion of intermediate part, with microspores.

II.—On the Guelph Limestones of North America and their Organic Remains.[1]

By H. Alleyne Nicholson, M.D., D.Sc., F.R.S E.,
Professor of Natural History in the University of St. Andrews.

Amongst the parallelisms which may be drawn between the Silurian series of Britain and that of North America, none so far has been so certainly established as the equivalency of the "Niagara Formation" to the Wenlock Group. In its most typical development, as in the State of New York, the Niagara formation consists of an inferior series of argillaceous sediments, the "Niagara Shales," and of a superior series of calcareous accumulations, the "Niagara Limestone." At the Falls of Niagara itself, and at the Falls of the Genesee at Rochester, the shales and limestones are about eighty feet in thickness each. In Pennsylvania, the Niagara formation is wholly shaly, and has a thickness of over fifteen hundred feet. In the States west of New York, again, the formation is almost wholly calcareous, many of its members being true dolomites, and its total thickness rarely reaches three hundred feet, and is usually much less. In Western Canada, finally, the Niagara shales can rarely be detected as a distinct group, and the formation consists mainly of limestones, often magnesian, with subordinate courses of shale, the whole usually varying from one hundred to two hundred feet in thickness.

Whilst the above are the general characters of the Niagara formation as developed in North America, I purpose in the present communication to discuss in greater detail a group of beds, which forms the uppermost member of the series in its most complete development, and which exhibits various points of special interest. The beds in question have the lithological character of magnesian limestone or dolomite; and, though not universally present, they are so constant in their position, and so sharply marked out by their organic remains, that they have been raised by the Canadian geologists to the rank of a distinct group, under the name of the "Guelph Formation," from the town of Guelph, where they are found in full force. This name has not been universally adopted; but it is convenient to use it, provided it be recollected that the deposits in question are in reality only a portion of the great Niagara Formation, of which they form the uppermost member. There are, however, strong grounds for believing, with Sir William Logan and Prof. Hall, that the Guelph Limestones, though found at points very widely remote from one another, do not form a continuous series, but that they are more or less of the nature of separate lenticular masses of unequal extent and thickness, which have been deposited on an uneven ocean bed towards the close of the Niagara period.

The typical development of the Guelph Limestones is found in Western Ontario, where they were first noticed and described (Murray, *Geol. Survey of Canada, Report of Progress*, 1848 *and* 1849; Hall, *Pal. N. Y.* vol. ii. p. 340; Logan, *Geology of Canada,*

[1] Read before the Royal Physical Society, Edinburgh, Feb. 17th, 1875.

1863). Here they occupy a band of country which may be roughly described as extending from near the western extremity of Lake Ontario to Lake Huron, and they attain their maximum thickness in the townships of Dumfries, Waterloo, Puslinch, Guelph, Pilkington, and Nichol. They are estimated to possess a total thickness of about one hundred and sixty feet, and they consist entirely of magnesian limestones, which are usually of a buff, white, or yellow colour. The subjacent strata, which constitute the mass of the Niagara Formation, though often consisting in part of beds of magnesian limestone, have a prevailing black, blue, or grey colour, and the Guelph dolomites are readily recognized by this alone. The texture of the rock is often highly crystalline, but it is commonly very porous or almost vesicular, owing partly to the existence of drusy cavities and partly to the numerous vacant spaces left by the weathering out of organic remains. The exposures of the Guelph Limestones which are best known are those found at Guelph, Galt, Hespeler, Elora, and Fergus, and in all these localities the rocks are charged with an abundance of fossils. Good specimens, however, are very difficult to procure, and the great majority of examples are simply in the condition of casts. Some beds of the formation yield a massive and valuable building stone; and others are burnt for lime, though in this latter respect there appears to be a prevailing preference for the cherty and siliceous limestones of the Corniferous series.

In the State of Ohio all the Limestones of the Niagara formation, with the exception of the celebrated "Dayton Stone," are magnesian, and the Guelph Limestones are consequently not distinctly marked off from the lower beds by any lithological peculiarity. The summit of the Niagara series in Ohio is, however, formed by a group of dolomites, which can be unhesitatingly identified with the Guelph formation of Canada, not only by the precise similarity in mineral characters, but also by the identity of organic remains. The Ohio geologists usually term these dolomites the "Cedarville Limestones," or the "Pentamerus Limestone." The latter name is derived from the great abundance in these beds of *Pentamerus oblongus*, Sow., a Brachiopod which is characteristic in Canada of the base instead of the summit of the Niagara series. The former name is derived from the great development of the series at the town of Cedarville, in South-western Ohio, where it is largely quarried, and where I had the opportunity of examining it last spring under the guidance of my friend Prof. Edward Orton, of the Ohio Geological Survey. As seen at Cedarville, and a few miles to the north at the village of Clifton, the Guelph formation consists wholly of beds of massive magnesian limestone, usually destitute of distinct lines of stratification in its lower portion. In appearance the rock presents the most striking similarity to the magnesian limestone of the same age in Canada, being of a yellowish or greyish-white colour, crystalline, rough to the touch, and rendered more or less vesicular by the presence of numerous cavities. Fossils are abundant, but are almost wholly in the condition of casts; whilst it is a matter of the greatest difficulty to obtain specimens that can be carried with comfort or convenience. Chemically the Cedarville Limestone is an almost typical dolomite, containing about 43 per cent. of carbonate of magnesia. In spite of this fact, it is reputed the best limestone in the whole State of Ohio for lime-burning, its lime not being "fiery," and taking much longer to "set," than is the case with lime made from ordinary limestone. The thickness of the Guelph Limestones in different parts of Ohio is estimated as varying between 20 and 90 feet. (*Geological Survey of Ohio, Report of Progress in* 1870, p. 278.)

Another development of the Guelph Limestones is known at the Leclaire Rapids on the Mississippi River, in the State of Iowa, where they were first recognized by Prof. Hall, and paralleled with the Canadian series. (*Geology of Iowa,* vol. i. p. 73.) The beds consist here of grey or whitish-grey magnesian limestones, of a semi-crystalline texture, and usually vesicular from the solution of fossils. No lines of true bedding are visible, and consequently the thickness of the series in this locality is unknown. Fossils are abundant, but wholly in the condition of casts. A yellowish-grey concretionary and false-bedded limestone identical with the above has been recognized at Port Byron, in the State of Illinois, where it has a thickness of about 50 feet. Limestones of the same age are likewise found in the vicinity of Chicago, also in Illinois, where it has the same general characters, except that it is highly charged with petroleum. (*Geological Survey of Illinois,* vol. i. p. 130 *et seq.*) Finally, limestones in all respects identical with the preceding, and holding many of the same fossils, have been recognized and described by Prof. Hall as occurring at Racine, in the State of Wisconsin. (*Geology of Wisconsin,* 1861.)

Organic Remains.

The organic remains of the Guelph Limestones are very numerous, comparatively speaking, and are many of them peculiar; but they are badly preserved, and only certain groups have been as yet worked out with any approach to fullness. The most highly characteristic fossils of the formation belong to the groups of the *Brachiopoda, Lamellibranchiata,* and *Gasteropoda;* but it will be as well to review briefly the more important forms which are known to occur in these deposits, without attempting to give anything like an exhaustive list.

The only recorded species of *Protozoa* from the Guelph Formation are two species of *Stromatopora.* One of these is the rare and interesting *S. ostiolata,* Nich.; the other is probably *S. concentrica,* Goldfuss; but its state of preservation is such as to forbid a positive specific determination. It is, however, an exceedingly common and characteristic fossil in the Guelph Limestones of Canada, whole beds appearing to be composed of very little else. In Ohio, I have not noticed its occurrence at all. The only other fossil which could be referred to the *Protozoa,* is a minute spherical body, of a calcareous nature, which occurs in myriads in some portions of the Guelph

Dolomites both in Canada and Ohio. Most usually the actual fossil itself has disappeared, and there is nothing left but the little cavity where it was situated; but in other cases the substance of the fossil has been preserved. Pending a microscopic examination of these problematical little bodies, nothing can be said of them beyond that they are very probably of the nature of calcareous sponges, and possibly belong to *Astylospongia.*

The corals of the Guelph Formation are neither very abundant nor very widely distributed. In Canada, the most characteristic corals are *Favosites polymorpha,* Goldf., *Favosites* (*Astrocerium*) *venusta,* Hall, and *F. hemispherica,* Yandell and Shumard, along with a species of *Amplexus* (apparently *A. Yandelli,* Edw. and Haime), and a fasciculate form which seems to be intermediate in its characters between *Amplexus* and *Diphyphyllum.* At Cedarville, in Ohio, I detected *Favosites Gothlandica,* Lam., an undetermined species of *Syringopora,* a large *Chonophyllum* allied to *C. perfoliatum,* Goldf., and numerous specimens of an ill-preserved species of *Cladopora,* resembling *C. reticulata,* Hall. *Halysites catenularia,* Linn., is also not of uncommon occurrence, and there are other forms which have not been satisfactorily determined.

The remains of *Crinoidea* are rare or unknown in the Guelph Formation of Canada; but very numerous and singular forms belonging to this group and to the nearly allied group of the *Cystoidea* have been found in the corresponding deposits in Ohio, Wisconsin, Illinois, and Iowa. Amongst the Crinoids, the more important forms belong to the genera *Eucalyptocrinus, Cyathocrinus, Actinocrinus, Melocrinus, Ichthyocrinus, Rhodocrinus,* and *Glyptaster.* Amongst the Cystideans, we have not only such well-known species as *Caryocrinus ornatus,* Hall, but we find forms belonging to the remarkable genera *Gomphocystites, Holocystites, Echinocystites,* and *Crinocystites,* together with species of *Apiocystites* and *Hemicosmites.*

The *Polyzoa* of the Guelph Formation have not as yet been worked out, so far as I am aware. In Canada, I have never succeeded in detecting any examples of this class in the Guelph dolomites; I found them, however, to be very abundant, though badly preserved, at Cedarville and Clifton in Ohio. The most abundant are *Fenestellæ,* belonging to at least three species. Very abundant, also, is a species apparently referable to Hall's genus *Lichenalia* (= *Cyclopora,* Prout?). A very similar form is found in the underlying Clinton Formation at Yellowsprings, a few miles to the north of Cedarville, and it constitutes one of the commonest and most characteristic fossils of the formation. The species is clearly distinct from *Lichenalia concentrica,* Hall, which occurs in the Niagara group proper, and seems more closely to resemble the *Cyclopora polymorpha,* Prout, of the Sub-Carboniferous series; but further examination will probably show it to be new. Lastly, there occurs a species of *Ptilodictya,* also apparently new.

The *Brachiopoda* of the Guelph Formation are individually very numerous, and are highly characteristic. Foremost amongst them come the Trimerellids, which the researches of Billings, Dall, Lindström, Hall, Davidson, and King have made palæontologists so thoroughly acquainted with. The most abundant members of this family are *Trimerella grandis*, Billings, *T. acuminata*, Billings, *Monomerella prisca*, Billings, and *Dinobolus Galtensis*, Billings. In Ohio, the most abundant species is *Trimerella Ohioensis*, Meek, which, though very local in its distribution, is in places common enough. After the Trimerellids, the most characteristic and abundant form is the great *Pentamerus occidentalis*, Hall, which is found both in Canada and the United States. In Ohio, however, the formation is so richly charged with *Pentamerus oblongus*, Sow., that it is often termed on this account the "Pentamerus Limestone;" whereas this well-known shell is in Canada, curiously enough, almost confined to a thin bed at the *base* of the Niagara Limestone. So strictly is this the case, that the bed in question, under the name of "the Pentamerus band," has usually been employed by the Canadian geologists to separate the Niagara Formation from the underlying Clinton Formation. Another not uncommon form is *Pentamerus* (*Pentamerella*) *ventricosus*, Hall; whilst other forms have been recorded belonging to *Spirifera*, *Charionella*, *Strophomena*, etc.

The *Lamellibranchiata* of the Guelph formation, so far as Canada is concerned, appear to be wholly referable to the remarkable genus *Megalomus*. Casts of the interior of the large and massive *Megalomus Canadensis*, Hall, are found in almost all the localities where the Guelph Limestones have been detected, though nowhere so abundantly as in Western Ontario. In some places, as in the cliffs of the Grand River below Elora, whole beds appear to be made up of this bivalve; but it is difficult to obtain specimens in which the actual shell is preserved. Another smaller species of the genus was described by Mr. George J. Hinde and myself from the Guelph formation of Hespeler, under the name of *Megalomus compressus* (Canadian Journal, vol. xiv. p. 143, fig. 6). In the Guelph Limestones of Wisconsin, in addition to *Megalomus Canadensis*, Prof. Hall has described species of *Lamellibranchiata* belonging to the genera *Ambonychia*, *Pterinea*, *Avicula*, *Cypricardinia*, *Modiolopsis*, *Amphicœlia*, *Cypricardites*, and *Palæocardia*.

Perhaps the most abundant and characteristic fossils in the Guelph formation—at any rate in Canada—are, however, the *Gasteropoda*. The three genera which are most largely represented are *Murchisonia*, *Pleurotomaria*, and *Holopea*, and of the first-named of these the variety of species is something quite extraordinary. Speaking generally, the following may be cited as being the most abundant and characteristic forms of the *Gasteropoda* in the Guelph formation:—*Murchisonia macrospira*, Hall; *M. Logani*, Hall; *M. turritiformis*, Hall; *M. Vitellia*, Billings; *M. bivittata*, Hall; *M. longispira*, Hall; *M. Estella*, Billings; *M. Hercyna*, Billings; *M. Laphami*, Hall; *Cyclonema* (?) *elevata*, Hall; *C. sulcata*, Hall; *Pleurotomaria solarioides*, Hall; *P. Elora*, Billings; *P. Galtensis*, Billings; *Holopea Harmonia*, Billings; *H. Gracia*, Billings; *H. Guelphensis*, Billings; *Trochonema fatua*, Hall; *Subulites ventricosa*, Hall; *Bucania angustata*, Hall; *Strapacollus Daphne*, Billings; and *S. Mopsus*, Hall.

Prof. Hall has likewise described from the Guelph formation of Wisconsin such well-known Niagara Gasteropods as *Platyceras Niagarensis*, Hall, and *Platyostoma Niagarensis*, Hall. At Cedarville, so far as my observation went, the Guelph Limestones are destitute of Gasteropods; but they occur elsewhere in the State of Ohio in this deposit in considerable numbers.

As regards the *Cephalopoda*, the Guelph Formation has proved in Canada to be very barren; but in the United States the same formation has yielded species belonging to the genera *Nautilus, Lituites, Orthoceras, Cyrtoceras, Gomphoceras, Phragmoceras*, and *Trochoceras*.

Finally, the Guelph Formation of Canada is almost destitute of the remains of Crustaceans. In Wisconsin, on the other hand, Crustaceans are not at all uncommon. Amongst these are such familiar forms as *Calymene Blumenbachii*, var. *Niagarensis; Illænus Barriensis*, Murch.; *Ceraurus insignis*, Beyrich; and *Sphærexochus mirus*, Beyrich. Besides these, there occur new and peculiar forms belonging to the genera *Illænus, Bronteus, Dalmannia, Acidaspis, Leperditia*, etc.

From the above brief review it will be seen that the fauna of the Guelph Formation is to a large extent a peculiar one, many of the known species being restricted to this particular horizon. The most characteristic features in the Guelph Fauna are afforded by the predominance of *Trimerellidæ* and *Pentameri* amongst the *Brachiopoda*, the great abundance and variety of the *Gasteropoda*, and the prevalence of the remarkable Lamellibranchiate genus *Megalomus*. These features are so general, that, taken along with the peculiar lithological characters of the rock, they justify us in regarding the Guelph dolomites as constituting a distinct series of deposits. At the same time, it is to be recollected that these deposits are clearly only a subordinate stage in the great Niagara Formation, of which they form an integral portion.

III.—Contributions to the Study of Volcanos.[1]

By J. W. Judd, F.G.S.

The Great Crater-lakes of Central Italy.

In no part of Europe, probably, can we find such striking examples of the effects which may be produced by single paroxysmal outbursts of volcanic force, as in the band of igneous rocks which stretches through nearly the whole length of the Italian peninsula, on the western side of, and parallel to the chain of the Apennines. Etna and many of the extinct volcanos of this continent constitute, it is true, mountains of vaster bulk than any in the district to which we have referred; but while the former were evidently built up by the accumulation of the products of igneous forces operating during long periods from the same centres, and with comparatively moderate violence, the enormous craters of the latter bear witness to the occurrence of single outbursts of these forces of far greater intensity.

The materials which have been ejected from the various centres of

[1] Concluded from page 308.

activity along this great volcanic band present many features in common; especially in the abundance of leucite and the group of minerals allied to it; there are also not a few points of peculiar interest in connexion with these rocks which have been very admirably treated by Professor vom Rath in his "Geognostiche-mineralogische Fragmente aus Italien." Without, however, staying to dwell upon these subjects, we shall proceed to notice the proofs which exist of the occurrence of those volcanic outbursts of extraordinary violence or duration to which we have referred, and which have resulted in the production of some of the most marked and striking of the physical features of the district.

The frequency of the occurrence of lakes in volcanic districts is a circumstance that is familiar to all geologists. Sometimes, as in the case of the Lac de Chambon in the Mont Dore, the throwing up of a series of volcanic cones in the midst of a valley has arrested the drainage, and given rise to the formation of a lake; in other cases, precisely similar effects have resulted from the influx of a great current of lava across a line of drainage. There are not wanting proofs, also, that those local subterranean movements to which volcanic districts are especially subject have frequently so altered the levels along a line of river-valley as to lead to the damming up of the stream, and to the consequent production of lakes. In all these cases the lakes have been formed by the joint action of aqueous and igneous forces. But there are also many examples of lakes the basins of which clearly owe their origin to the action of igneous causes alone. Such are the well-known Maare of the Eifel, and those numerous depressions common in almost all volcanic districts, which are evidently old craters that have become filled with water.

But lying to the northward of Rome we find two lakes of such vast proportions—the Lago di Bracciano being $6\frac{1}{2}$ miles in diameter, and the Lago di Bolsena 10 miles—that we may at the first sight of them be fairly led to hesitate in referring their formation to the ordinary explosive action of volcanos. Dr. Daubeny, indeed, appears to have been so staggered by their enormous size, that he found it impossible to accept their volcanic origin. In the present chapter we purpose to notice those features presented by them which appear to place their mode of formation beyond question.

In seeking to illustrate the characters and to account for the production of these vast craters, it will be well to refer, in the first instance, to examples of a precisely similar kind, though on a somewhat smaller scale, the mode of origin of which it is not possible to doubt. Vesuvius presents us with a great encircling crater, that of Somma, which has a diameter of two miles and a half, and which was produced during the grand paroxysmal outburst of A.D. 79. There seems to be now no room for doubt that at the period of this grand eruption, concerning which we possess such interesting historical details, the original cone of Somma was completely gutted, and that vast cavity formed in the midst of which the existing cone of Vesuvius was subsequently built up. Here, then, we have an illustration of the effects which may be produced by a single eruption of a volcano, and may fairly employ it for comparison with others, concerning the formation of which we have neither historical records nor traditions to aid us, and which may possibly indeed have originated prior to the appearance of the human race upon the earth.

Such an example we have in the great volcano of Rocca Monfina, which presents so many points of analogy with Vesuvius that the geologist will have no difficulty in recognizing the mode of origin of the principal features of the former, though it has long been extinct, and its rocks have suffered greatly from the action of denuding forces.

The mountain group of Rocca Monfina exhibits a crater-ring of about three miles in internal diameter, that is to say, it is somewhat greater than the similar crater-ring of Somma, which surrounds the modern cone of Vesuvius. The materials which compose these older encircling craters of Somma and Rocca Monfina are almost identical, namely, leucitic basalts and the tuffs derived from them; but it is clear that while in the former the lavas form a very large proportion of the mass, in the latter they are quite subordinate to the tuffs, of which the volcano is mainly built up. In the centre of each of these old craters rises a more modern volcanic cone, but of very different characters in the two cases. While Vesuvius is composed of lavas and tuffs quite similar in character to those of Somma, the Montagna di Santa-Croce, which has risen in the midst of the old crater of Rocca Monfina, consists of vast hummocky masses of a peculiar rock—a "trachy-dolerite," with much mica. That the crater-ring of Cortinella (which embraces the mountain produced by later eruptions, in the same manner that Somma does Vesuvius) was formed by similar explosive action to that which we know gave origin to the latter, no one can doubt who observes the exact correspondence in all the characters of the two mountains. The only difference between them is this—that while Somma, after the great paroxysm which destroyed all the higher and central portions of its mass, continued to pour forth those similar leucitic lavas and tuffs by which the modern cone of Vesuvius was gradually built up, Rocca Monfina, by a change not uncommonly witnessed at centres of volcanic outbursts, began to originate materials of a different composition and mode of behaviour, namely, the more acid lavas of much less perfect liquidity which formed those great bosses in the centre of its crater constituting the mountain-masses of Santa-Croce.

Proceeding still to the northwards, we find, a little to the south of Rome, a third volcanic group, that of Monte d'Albano, composed of similar leucitic basalts and tuffs to those of Vesuvius and Rocca Monfina. In the centre rises Monte Cavo, which we may justly compare to Vesuvius; it is a volcanic cone, with a well-marked crater at its summit, upon the floor of which rise the remains of several smaller cones, now weathered down and grass-grown. Monte Cavo, like Vesuvius, is embraced by a great crater-ring, broken away on its western side by the later parasitical eruptions which have originated the craters of Vallariccia, Lago d'Albano, Lago di Nemi, and the craters about Frascati. But while the outer crater-ring of Somma has an internal diameter of only two miles and a half, and that of

Rocca Monfina of three miles, the similar crater-ring of Monte Albano is not less than six miles in internal diameter; and it is, moreover, almost wholly composed of volcanic tuffs. In spite, however, of the difference of size, no geological observer can for a moment doubt that the exact identity of relation between Vesuvius and Monte Cavo, and their respective encircling crater-rings, points to a similarity in their mode of origin; and of what that was in the case of the former we have actually historical evidence.

North of Rome rises another volcanic group—that of the Lago di Bracciano. In this case we find a great circular hollow of almost precisely the same dimensions as that of Monte Albano, and composed of identical materials, namely, leucitic tuffs, with a few currents of lava. The circular mountain group that incloses the Lago di Bracciano only differs from that at Albano in the circumstance that no central mountain rises in its midst. The great hollow occupied by the Lago di Bracciano is nearly circular in form, and about $6\frac{1}{2}$ miles in diameter. The surface of the lake is 540 feet above the level of the sea; while the highest point of its surrounding wall, the hill known as the Rocca Romana, rises to a further height of 1,486 feet. On its western side the inclosing ring of hills has been cut through by the River Arrone, which affords an outlet for the waters of the lake. It appears clear that the excavation of this river valley has effected a gradual lowering of the level of the Lago di Bracciano, in a manner similar to what was suddenly effected, by artificial means, in the case of the lakes of Albano and Nemi by the ancient Romans. A few scattered outbursts of the volcanic forces have evidently taken place in the immediate neighbourhood since the grand catastrophe by which the vast crater was formed; and numerous hot and mineral springs all around bear witness to the fact that the igneous forces are not even yet wholly extinct beneath it.

The Lago di Bolsena is less perfectly circular in form than the Lago di Bracciano; its length from north to south is $10\frac{1}{4}$ miles, and its breadth from east to west nine miles. The lake lies in the midst of a group of hills, wholly composed of volcanic rocks, which rise gradually from the plains to heights of from 1,200 to 1,500 feet above the sea. The surface of the waters of the lake is 962 feet above the level of the Mediterranean, and the ring of hills around it constitute heights for the most part from 300 to 500 feet above it. Some few points in this crater-ring are, however, of considerably greater elevation, as San Lorenzo on the north, Valentano on the south, and Montefiascone on the south-east, which are respectively at heights of 684, 780, and 985 feet above the level of the waters of the lake. The last-mentioned point, however, owes its great elevation to a later eruption, the town being built on the summit of a cinder-cone which has been thrown up on the very edge of the crater-ring, evidently at a period subsequent to its formation. Like that of Bracciano, the crater-ring of Bolsena is cut through by a river-valley, that of the Marta, which affords a means of escape for its waters on its south-western side; and it is clear that by the excavation of this channel the surface of the lake has been gradually lowered.

The lake of Bolsena differs from that of Bracciano in having two islands, known as Bisentina and Martana, rising in its midst. These are composed of volcanic tuffs, and present the peculiar quaquaversal dips so characteristic of cinder-cones. These are evidently the remains of two small cones, which have been thrown up on the floor of the great crater, by eruptions subsequent to the great paroxysm which produced its main features.

The series of craters which we have now described possess so many features in common that it is very instructive to notice such points of difference as exist between them, since these may serve to illustrate the various changes, both in the nature and products of their action, which volcanic centres may undergo.

In Somma we find a crater with a diameter of two miles and a half, the actual formation of which is described by historians; while the materials ejected in the course of its production still lie thickly over the ruins of buried cities. Within this crater a cone—that of Vesuvius—has grown up, and has been in great part destroyed and re-formed several times during the last eighteen centuries. In Rocca Monfina a crater-ring of almost identical character, but of somewhat larger dimensions and older date, has had extruded within its area bosses of bulky crystalline rock, apparently of so viscid a character at the time of their emission as not to be capable of being scattered in scoriæ, or of flowing in lava-streams. To pass from these craters to those of Monte Albano and the Lago di Bracciano (of which the diameter is almost twice as great) may at first sight, perhaps, present some difficulty; but if the exact correspondence of all the features, except those of size, between Somma and Vesuvius on the one hand, and the outer ring and central cone and crater of Monte Albano on the other hand, be considered, no one can possibly doubt the similarity of their modes of origin. The contrast is sufficiently obvious between what must have occurred in the case of the latter volcanic group, where a central cone of vast dimensions has been built up by eruptions subsequent to the grand paroxysmal outburst that gave origin to the outer crater-ring and in that of the vent of Bracciano, which became quite extinct after its final grand effort. In the Lago di Bolsena a paroxysm, of such violence as to produce even a still larger crater, was followed by feebler outbursts, that only sufficed to form two small cinder-cones within its vast circuit.

It is not surprising that the vast size of these great lakes of Bracciano and Bolsena should have led some to entertain doubts as to the possibility of their having been formed in the same way as ordinary craters—that is, by explosion. But if a sufficiently large series of these objects be studied, it will, we think, be found impossible to draw any clear line of distinction between those of the most moderate dimensions and those which attain such vast proportions, or to ascribe to the latter any different mode of origin to that which has so clearly produced the former.

Without passing beyond the district with which we are now immediately concerned, the truth of this statement may be made clearly apparent. In the Campi Phlegræi we have several beautiful examples of crater-lakes, such as Agnano and Avernus. Both of these are less than one mile in diameter, and there is no more room for doubting their mode of origin than there is for questioning that of Astroni, which is a crater with a very small lake in its midst, or indeed of that of Monte Nuovo, the formation of which was actually witnessed only three centuries and a half ago. But in the immediate proximity of these are the precisely similar crater-rings of Pianura and the Piano di Quarto, which, although having diameters of three and four miles respectively, are nevertheless so precisely similar in character that it is quite impossible to assign to them a different mode of origin.

Again, the formation of the crater-ring of Somma is an event of which we have authentic records, and it is impossible to doubt that an eruption on even a still grander scale must have originated the precisely similar crater surrounding Monte Albano; while, if this be admitted, the analogous crater-rings of Bracciano and Bolsena cannot but be assigned to the operation of similar causes.

Indeed of the recent formation of a crater of even as vast dimensions as those which we have described as existing in Italy, we have an example in the grand eruption of Papaudayang, in Java, in 1772, by which a gulph no less than fifteen miles long by six broad was originated!

Accepting then the conclusion that even the vast circular lakes of the Italian peninsula have been formed by explosive outbursts, similar in character to, but of greater intensity or duration than some of those which have been recorded during the short periods to which history or tradition goes back, we may proceed to ask, what are the causes which have led to the production in different cases of very dissimilar structures by the same explosive action?—namely, of cones like Monte Nuovo and Etna, on the one hand, having comparatively small craters at their summits, and of vast craters like the Piano di Quarto and the Lago di Bolsena, in which the surrounding wall is of comparatively insignificant bulk and elevation. In making this distinction, however, it must be borne in mind that no strong line of demarcation exists between the two classes of objects. Between almost perfect volcanic cones, exhibiting at their summits quite insignificant craters and pit-craters with scarcely a vestige of a crater-wall, examples illustrating every conceivable stage of gradation may be cited.

It is clear that, as a general rule, the formation of volcanic *cones* must be assigned to the operations of comparatively moderate explosive force, either long continued or oft repeated; while that of pit-craters must be due to comparatively short, sudden, and violent outbursts.

That the cause which produces both classes of volcanic vents is no other than the expansive force of bodies of steam, which are disengaged from masses of incandescent lava rising through fissures towards the surface, is a fact now universally recognized. And to the geologist familiar with the appearances presented by such fissures, as filled with the now consolidated materials to which they gave passage, and exposed beneath what were once eruptive vents, through the removal by denudation of the overlying volcanic structures, a cause for the varying modes of action at different points of the same volcanic district may readily suggest itself.

The great fissures filled with consolidated materials, which penetrate older rocks in volcanic areas that have suffered great denudation, affect two very distinct modes of arrangement. They are either cracks which traverse the strata vertically, or fissures which have been formed through the yielding of the planes of least resistance among the strata themselves. The former, filled with consolidated lava, become dykes; the latter, intrusive sheets.

That the fissures of both classes sometimes reached the surface, and that, in such cases, they gave origin to volcanic outbursts, we have very unmistakeable evidence. But it is also clear that the action which would take place at the surface in the case of the two kinds of fissures would necessarily be very different. In the case of a vertical fissure, the smallest communication with the surface would lead to a local disengagement of vapour, and this relieving the pressure on the mass below, continually fresh supplies of steam would be liberated, carrying up fragments of the liquefied rock in which it was imprisoned as scoriæ or pumice, or forcing it out in streams as lava. Thus would naturally be built up, according to circumstances, a cone of cinders, a composite cone of cinders and lava, or a solid cone ("mamelon"), wholly formed by the welling out of the latter material. But in the case of a horizontal fissure, the result would probably be very different. Here the mass of lava, which, as we know, may be forced for many miles away from the volcanic centre, would have its imprisoned water retained by the superincumbent rocks till it reached a point at which, either from a decrease in the thickness or a diminution in the capacity for withstanding expansive force of the superincumbent rock, it began to be disengaged. Then an accumulation of vapour of the highest tension would begin to take place, and by its accumulated force, the repressive power of the overlying rocks being at last completely overcome, the latter, throughout a wide area, would be shattered to fragments and dissipated in one short, sudden, and violent outburst. But the mass of lava to which this outburst was due, having beneath it no further reservoir from which steam could be disengaged and rise to the surface, the first violent outburst would not be succeeded, as in the case of vertical fissures, by a series of similar explosions.

By the liberation of vapour in vertical and horizontal fissures respectively, then, it seems possible to account for the formation in the same district, as in the Campi Phlegræi, of the two very distinct kinds of volcanic vents, or for the appearance of either class almost alone, as in the Eifel and the Auvergne.

But though this explanation may suffice to account for the production of those smaller vents which occur in such areas as we have referred to, yet it is evident that the formation of enormous craters like those of Bracciano and Bolsena is a problem of a different and perhaps far more difficult character.

If, for example, we were to conceive of an eruption of so violent a character as to blow into the air all the central portion of Etna, so as to leave a crater of many miles in diameter, the result would be not very different from the vast lake surrounded by a rim of comparatively small elevation, which we witness in Bracciano and Bolsena. But here we are met by the fact that, in Italy, at least within the historic period, no such mountain as Etna has ever been so destroyed by a volcanic outburst as to leave only a basal wreck consisting of a wide and low crater-ring.

Etna is an admirable type of a *well-built* volcano. As shown in the splendid section of the Val del Bove, lava-streams, dykes, and agglomerates are combined together into a framework of the most solid character. As the structure has risen in height, the weakest portions of its flanks have successively yielded to the vast expansive forces below, and fissures being produced, these weakest parts have been successively repaired and strengthened, first by the injection and consolidation of lava in the fissures, and secondly by the piling up of materials above them. Thus the grand cone has grown, by the alternate strengthening of its flanks through lateral outbursts, and the renewal of ejections from its axial crater, as the vast chimney became sufficiently strong to sustain the pressure necessary to raise the materials to the lofty summit of the mountain. That this has really been the process of growth in Etna, no one who studies its enormous bulk, its numerous parasitical cones, and its clear sections, can for one moment doubt.

But as we have already pointed out, the wide and little elevated crater-rings of Albano, Bracciano and Bolsena present a totally different kind of architecture to the solid structure of Etna. They are in fact almost wholly built up of loose tuffs; masses of solid lava, whether in currents or dykes, being few, and forming but a very small proportion of their bulk.

The action of expansive forces within cones almost wholly composed of such loose materials would necessarily be very different from that which we have seen takes place in Etna. Lateral eruptions would become almost impossible, for as soon as any part of the flanks of the mountain began to yield to the rending force, the loose materials at the sides of the fissure would close in and fill the crack as rapidly as it was formed. That this is no hypothetical explanation of what takes place in such tuff cones is shown by the numerous beautiful pseudo-dykes, filled with fragmentary materials, which occur in the tuff-cones of the Campi Phlegræi, and the almost total absence in these cones of dykes of solid lava.

The expansive force of the vapour, gradually separated from the incandescent masses of lava below the mountain, being thus unable to open any safety-valve by producing a lateral eruption, would at last attain such tension as to enable it to dissipate the whole structure of the cone itself, composed as it is of loose and uncompacted materials. These by repeated ejection would be reduced to fine fragments, which would be deposited as tuff and ash over enormous areas all around the vents. The craters of Albano, Bracciano, and Bolsena are in fact surrounded by such deposits, which extend over a wide district around them.

Vast, then, as are the dimensions of the great crater-lakes of Central Italy, it is impossible to doubt that they have been formed by the same causes which have originated the numerous others of smaller size, but of similar character, within the same district,—namely, the explosive action of steam disengaged from masses of lava below them. Nor does it, in the case of these vast craters, seem possible to admit of their areas having been enlarged subsequently to their formation by any kind of erosive action. Not only is there no evidence whatever that these craters have been submerged beneath the ocean; but, on the contrary, the narrow rivers and valleys by means of which the waters of both Bolsena and Bracciano are carried off, as well as the loose cinder cones in the midst of the former, point to an exactly opposite conclusion. Neither does the action which Mr. Brigham points out as taking place within that vast lake of liquefied rock, Kilauea, namely, the encroachments of the mass of incandescent liquid upon its walls, by which these are slowly eaten back, appear to throw any light upon the formation of the great Italian craters; so very different in composition and behaviour are the lavas of Italy and Hawaii respectively. All theories of an engulphment of the central masses of the volcano completely fail to explain the regular circular form of these depressions, and their striking similarity to those of smaller size, which have evidently been produced by explosive action.

Nor, when we reflect on the small portion of the earth's surface, and the very short periods concerning which we have any records of the nature and results of the physical changes that have taken place upon it, need we hesitate to admit that paroxysms may have occurred which, though similar in kind, yet exceeded in their degree of intensity any which man may have had an opportunity of witnessing or recording.

IV.—Glacial Erosion.

By J. G. Goodchild, F.G.S.;
Of H. M. Geological Survey of England and Wales.

(*Concluded from page* 328.)

Any one who compares the terraces that are shaped by rivers and the sea with the terraces that are found in the Yorkshire Dales must see that in the one case the denuding agent has acted alike upon beds of all degrees of hardness, and has shorn off the edges of the rocks to one level, whether the strata were horizontal or inclined; in the other case the denuding agent has acted unequally upon the rocks according to their varying powers of resistance, so that the harder beds were left in relief; and, so far from being all shorn off to one level, it would perhaps be difficult to find any one of the Dale District terraces that is not more or less inclined. The bases of the cliffs formed by the one denuding agent are quite level: those left by the other are often inclined many degrees.

It will perhaps be remarked that the peculiarities of the Dale terraces are just what one ought to expect if they are the result of

Subaerial Denudation. Even where there is no stream to remove the weathered material as fast as it falls, some geologists would probably consider the combined action of springs and the weather quite sufficient to give rise to the features in question. But in the particular district here referred to there seems to be evidence to prove that this view is incorrect. It will perhaps be sufficient to refer to the following points in confirmation of this. Wherever springs are found in such a series of alternations of beds of different lithological character as forms the hills of the Dale District, they usually occur at irregular and often at distant intervals along the bases of the more permeable beds. In most cases, especially in the lower beds, the springs issue at the line of junction of a limestone with the more or less impervious bed that it lies upon. Most of the spring water thus thrown out has usually flowed only a short distance under ground; in the generality of cases the water that flows over the surface of the usually impervious bed above sinks as soon as it reaches the open joints of the limestone and collects over the next impervious bed beneath, by which it is again thrown out to the day. Thus it follows that, where little water finds its way on to the limestone, as little is thrown out as springs; but where the limestone is near the edge of a considerable flat, especially if there is also a peat moss near, springs of considerable size make their appearance. The steep slopes of the fell-sides in the dales usually prevent the wide spreading of any great quantity of water, which for the most part finds its way to a lower level without forming many springs in its course; but high up on the fell-sides, near where the flatter surface begins to be covered with peat mosses, the greater part of the water that comes down the fell-sides issues from the springs that are found along the base of the highest thick bed of limestone. In other words, at low levels there are found but few springs, and those only small: while in the higher parts the springs are both numerous and of comparatively large volume. When we compare the forms of the scars in the two places, it is at once apparent that where there are but few springs, that is to say, in the low ground, the characteristic sweeping outline and general uniformity of character of the scars, is retained; while where there are many springs, as in the higher parts, the wide and irregular notches that break the regularity of the scar's outline, and the accumulation of fallen blocks that have been undermined, plainly indicate that the springs are slowly destroying the present regularity and replacing it by a form of surface altogether different. To put this in another form:—where there are no springs we get the most perfect outline and a surface without much fallen rock: where there are many springs the rock features present a broken and irregular outline, and the slopes beneath are encumbered with the rock thus degraded. Again, the springs do not come out at regular or at close intervals, but are confined to certain positions that are usually determined by either the lie of the rocks or the general direction of the streams whence most of the water is derived. To produce anything like the regularity of form that one sees in the scars, the springs must have acted at regular and close intervals all along the line; and each must also have accomplished only a certain definite amount of cutting back before its position again changed. Even granting that it is possible for springs to cut back an escarpment with a certain total amount of regularity, it is clear that, unless there are at hand larger streams to remove the undermined rock, the springs would soon become so much choked up that their action would no longer be effectual. In other words, if the rate of removal do not keep pace with the rate of disintegration, the accumulating talus would soon protect that part of the scar from much further alteration. Another objection to the spring theory is that nearly all the denudation effected by the springs would be confined to beds above the impervious bed that throws them out; hence, if the limestone scars are really the result of spring action, we ought to find the limestone scar in all cases at a considerable distance nearer the centre of the hill than the outcropping edge of the sandstone that forms its base. Instead of this, we find, in nearly every case but that where the limestone directly overlies a soft bed, that the limestone scar forms part of one continuous slope with the outcrop of the sandstone beneath. Hence the conclusion seems inevitable that both scars were formed at the same time and by the same agencies. Lastly, some of the terraces whose origin is here discussed have a width of two hundred or three hundred yards, or even more than that; yet the outer part of the terrace, that is to say, the part nearest the marginal scar, usually exhibits no greater amount of weathering than does the innermost part close to where the next bed above comes on. If then the terraces have really been produced by Subaerial Erosion acting unequally upon beds of different degrees of destructibility, it follows either that the overlying shales have been cut back from the limestone at a greater rate than we have evidence for; or else, if the time occupied in cutting them back has been long, the weather has no appreciable effect upon the limestone after this has undergone a certain amount of subaerial erosion. Yet there is clear proof that, under circumstances the most favourable, so soft a rock as shale has rarely been cut back far in Post-Glacial times; therefore it is clearly impossible that a much larger quantity can have been removed in the same time in situations where no stream could possibly flow under anything like the present physical conditions. The alternative that after a time the limestone ceases to undergo any further erosion needs no other argument to disprove it than that afforded by the position and shape of the swallow-holes. Under subaerial conditions the streams that gave rise to the swallow-holes must be continually cutting back the soft beds overlying the limestone from the point where the stream first reached the limestone towards the watershed. Consequently, the swallow-holes that were first formed would either remain in their original shape and position to mark where the stream first began to sink, or else would tend to lengthen in the direction of the source of the stream, as the point where this first reached the limestone slowly receded towards the watershed. Hence the swallow-holes, instead of retaining a rudely circular form, would change first into the form of an ellipse, and then gradually become longer, until they extended from the point where they were initiated right across the terrace to the very inner margin. If the rate of recession of the scar at the edge of the terrace were equal to that of the overlying bank of shale, the first formed swallow-holes would soon be cut back too, and we should then find a series of ravines extending across the whole width of the terrace.

It need hardly be repeated that nothing of the kind is to be found in the part of the Dale District here referred to: perhaps it would be difficult to find a single instance of such a series of ravine-like swallow-holes in the entire Dale District.

Now it is clear, as was pointed out above, that the existence of these terraces has been determined, not by the capacity of the rocks that form them to resist subaerial erosion, but by their relative powers of resistance to erosion by *mechanical means.*

Bearing these facts in mind, and reflecting upon the regular forms of the scars; their parallelism with others above and below; their frequent correspondence in form with others on the same horizon across valleys a mile or more in width; the existence of perfect scars and terraces many hundreds of feet above where, under existing physical conditions, it would be possible for any stream to produce them; the uniformly weathered surface of the limestone and the restriction of the principal swallow-holes to the inner margin of each terrace; the general absence of much debris from the higher beds; and, finally, the existence of glacial markings close to the inner margins of some of the widest terraces — we may well hesitate to accept any theory whereby the origin of these characteristic rock features is referred to Subaerial Erosion.

At least as early as the summer of 1868 Prof. Hughes, when we were together surveying part of the district referred to, expressed a doubt whether any one of the Subaerial Denudation theories was adequate to account for all the facts connected with the rock features of that district; at the same time he stated his belief that no small share in the development of the surface characteristics of the Dale Rocks must be attributed to the action of land-ice. Since then an increasing acquaintance with the physiography of a large area of the Upper Palæozoic rocks adjoining the Dale District has increased my conviction that the theory put forward by Prof. Hughes is the only one that really sorts with the facts.

In the communication referred to at the head of this paper I have stated my reasons for believing the former existence in the Dale District of an ice-sheet of such a thickness that it overtopped the highest fells; therefore its surface could not have been much less than 2300 feet above the level of the sea. Nearly everywhere at high levels the ice seems to have flowed away from certain pretty well defined lines and centres without being much influenced by the form of the underlying low ground; while in proportion to its nearness to the bottoms of the valleys it seems in general to have been more and more guided by the configuration of the adjoining surface, in the manner so often spoken of by Prof. Ramsay.

The flow of the higher strata of the ice seems to have been mainly guided by the position of the adjoining higher fell tops, while the lower strata seem to have been guided in their course by the sides of the old preglacial valleys and to have flowed steadily outwards nearly like a modern glacier.

Whatever difference of opinion there may be amongst geologists with regard to the theory that I have elsewhere put forward, that the great ice-sheet was charged with detritus throughout, there can hardly be any with regard to the existence of stones between the ice and the rock surface that it covered. It must be borne in mind that when the Glacial Period set in the ice must have had to work at a surface that had been exposed for ages to the attacks of subaerial forces, and that, in consequence, all the rocks were weathered to a great depth. What that depth was has never yet been determined; but, if we may judge by the rapid rate which many rocks weather in a single lifetime, we should be prepared to find that the amount of weathering effected between the close of the next older Glacial Period and the commencement of the latest was far in excess of anything of the kind that we can now point to in these islands. I have long held the opinion that it was this preglacially-weathered rock that formed the bulk of the materials of the drift.

When, therefore, the early glaciers began to invade the lower parts of the valleys, the removal of the surface rock, loosened as it was by long-continued weathering, must have been a comparatively easy matter. At the outset, on account of the deeply-weathered joints in the harder kinds of rock, their rates of erosion would be nearly equal. But as soon as the weathered outer portions of the limestones and sandstones were removed, the unweathered rock beneath would be better able to withstand the grinding of the ice than would the associated softer flags and shales. As a consequence, the softer beds were eroded much faster than the interbedded harder rocks, which would thus be left in relief as terraces. The remarkable capability of the ice to adapt itself to every form of the surface, which the glaciated surfaces of the North of England plainly show the ice must have possessed, must have helped greatly to produce such a result. Wherever the ice passed over a soft bed that had one much harder immediately beneath it, the overlying bed was removed with comparative ease; while the newly bared upper surface of the harder rock beneath offered much greater resistance to the grinding of the ice and consequently suffered much less erosion. In the case of some of the more compact and thickly-bedded rocks, it seems that the highest strata of the hard bed even yet form the upper surface of the terrace a hundred yards or more from the outcrop of the overlying soft bed.

In connexion with this part of the subject there is one point that seems to have been overlooked by many of those who have written about the vertical limit of the ice-sheet. It has been assumed, seemingly upon insufficient grounds, that the rough and craggy form of the higher parts of districts that are well glaciated in their valleys is good proof that these higher parts were never overridden by the ice. But if the view here advanced be correct—that the ice removed from the low ground all the weathered parts of the rock—it follows that, because the stay of the ice at the higher points was brief as compared with its stay lower down, much less of the high lying weathered rock was removed; and consequently, when the whole surface became again exposed to the action of subaerial agencies, the sound rock of the low grounds would be long in being affected, even where it was not covered by drift, while at the higher points subaerial denudation would soon remove the slightly glaciated surface and replace it by another that would appear to have been always out of the reach of the ice. Thus it is that in the Dale District the higher lying rock surfaces show more decided traces of the action of the weather than are to be found nearer the bottoms of the valleys. The thorough glaciation of the low ground caused all the preglacially weathered rock—swallow-holes, widened joints, and all—to be removed; whilst at higher levels even a considerable portion of the preglacially weathered rock was left. In the one case the weather has had to begin its work anew; in the other it resumed work almost where it ceased. The same remarks will of course apply equally to those parts of Mid and Southern England where the presence of glacial drift marks the former extension of the ice-sheet. When compared with its duration in the Northern parts of England, the stay of the ice-sheet in the South was probably brief. Hence there would be less modification of the rock surface than was effected where the ice had a longer stay. Consequently, the slight amount of erosion that the rocks underwent would favour the rapid replacement of an ice-worn surface by one that to all appearance had been produced solely by atmospheric causes.

With regard to the quantity of rock removed from parts that had long been exposed to glacial action, there does not seem anywhere to be any satisfactory evidence. But when we reflect upon the immense numbers of the boulders of almost every rock of marked lithological character that have been dispersed far and wide from outcrops of small extent, it is at once apparent that other rocks that, as boulders, are not so easily followed, have, under a like amount of glaciation, suffered denudation to as great an extent. The well-known granite of Shap is a familiar instance. From a superficial area of about a square mile and a half, lying just to the north of the Lake District Watershed, and in such a position as to be long out of reach of the ice, immense numbers of blocks have been dispersed in an easterly direction from the Fell itself, over Stainmore, and far and wide over the country to the East at least as far as the North Sea; while, owing to the southern overflow of this part of the Eden Valley ice consequent upon the inflow from Scotland, great numbers of the same boulders have been carried backward in the higher parts of the ice, over the watershedding line, and away South by Lancaster, Preston, and Chester, at least as far as the Vale of Gloucester. What is true of any one rock therefore, must, under like circumstances, be equally true of those that it is associated with; from this it seems a fair inference that the quantity of rock removed from the surface of the lower lying Dale rocks must be at least equal, area for area, to what was removed from Wastdale Crag. Hence we are led to the conclusion that the ice-sheet effected some very important modifications of form in the old preglacial valleys. Where the ice remained for long periods, there can hardly be any doubt that many of the valleys were both deepened and widened, in some instances to a considerable extent; and also that the peculiar mode of action of the ice tended everywhere to modify the pre-existing form of the surface and even to replace part of this by sculpturing that is very different from anything that, under existing physical conditions, could possibly be produced by any kind of Subaerial Erosion.

The origin of these terraces and scars of limestone has, perhaps, been dwelt upon here at greater length than its importance might at first seem to require, because the existence of such features in a rock so easily affected by atmospheric agencies as limestone is affords us a clear proof that whatever left them in so high relief beyond the associated less-easily weathered beds was an agent that acted with greatest effect upon those rocks that could least withstand mechanical erosion and disregarded their varying power of resistance to erosion by Subaerial means.

We know that the valleys where these features occur were at one time filled to the highest points with ice; we also know by the position of certain marks of glacial origin that but little atmospheric erosion has been effected at those points in Post-glacial times; hence the conclusion seems inevitable that all the rock features whose origin cannot be referred to any form of Subaerial erosion, but which are clearly due to erosion by some mechanical means, have been the work of the ice. Not only the terraces of limestone, but the associated terraces and scars of sandstone and grit, must have originated in the same way. Hence one is led to regard nearly all the more prominent rock features of these well-glaciated parts as in one way or another the result of Glacial Erosion.

V.—A Chapter in the History of Meteorites.

By Walter Flight, D.Sc., F.G.S.,
Of the Department of Mineralogy, British Museum.

(*Continued from page* 320.)

1790, July 24th.—Barbotan and Roquefort, Landes, France.[1]

A correspondent communicated to *Nature* a reference to a description of this celebrated fall of meteorites, which is to be found in Gruithuisen's *Naturgeschichte des gestirnten Himmels* 407. As it does not appear to have been known to Buchner, it may be placed on record here.

1803, April 26th.—L'Aigle, Orne, France.[2]

While at the end of the last century reports from time to time obtained circulation, to the effect that stones had been seen to fall from the sky, and while these reports were generally discredited as

[1] *Nature.* February 1st, 1872.
[2] E. H. von Baumhauer. *Archives Néerlandaises*, 1872, vii. 154.

fabulous, a desire had arisen among the curious to collect and preserve them, and even to submit to careful study these strange mineral masses, to which an atmospheric origin was attributed. It was at this time that Howard and De Bournon made a careful examination of the stones reputed to have fallen from the sky, which were contained in the mineral collection of Greville; and, after observing them to possess certain characters in common, as well as others which distinguished them from terrestrial matter, they were led, in the *Philosophical Transactions* of 1802, to give their support to the views, then regarded as purely fantastic, which Chladni had propounded in 1794 in his remarkable memoir *Ueber den Ursprung der von Pallas und anderer ihr ähnlicher Eisenmassen.* The new view had in fact found little favour among scientific men, especially in France, and De Bournon and the French *savant* Patrin were engaged in a controversy on the subject at the beginning of 1803, when the celebrated fall at L'Aigle, of from two to three thousand stones, took place. The first news which reached Paris was received with a smile of incredulity; the illustrious Biot, however, was deputed by the *Ministre de l'Intérieur* to proceed to L'Aigle and institute a full inquiry, which lasted many days; and his exhaustive report, which appeared in the *Memoires de la classe des Sciences math. et phys. de l'Institut national de France,* finally set the question at rest, and established the fact that the stones were of cosmical origin, and the truth of Chladni's theory.

These meteorites were analysed by Thénard, who found in them silica, iron oxide, magnesia, nickel, and sulphur, amounting in all to 108 per cent.; and afterwards by Fourcroy and Vauquelin, who detected the presence of the same ingredients and lime in addition, the total amounting to 104 per cent. The excess of course was due to the fact of the metal present as such in the meteorite being accounted oxide in their calculation.

In consideration of the past historical importance of this fall, it occurred to von Baumhauer to submit the L'Aigle meteorite to analysis by the new and elegant methods which he has devised and employed with so much success on other meteorites. His results are given below. The specific gravity of the stone is 3·607, and the total composition is as follows:—

Nickel-iron	8·0
Iron sulphide	1·8
Chromite	0·6
Olivine	45·3
Silicate unacted upon by acid	44·3
Lime sulphate	trace
	100·00

After the removal of the nickel-iron, the treatment with acid and sodium carbonate brought about a separation of the varieties of silicates, which had the following composition:—

	SiO_2	FeO	MnO	Al_2O_3	CaO	MgO	K_2O	Na_2O	
A. *Soluble*	35·16	30·39	trace	0·18	6·16	26·51	0·85	0·75	= 100·00
B. *Insoluble*	57·16	12·56	trace	5·19	4·08	17·91	2·02	1·07	= 99·99

The oxygen ratios of acid and bases in the soluble part 18·63 : 19·53 show the silicate which gelatinised with acid to be an olivine, remarkable, it should be observed, for the amount of lime it contains. Von Baumhauer gives the formula $\left(\begin{smallmatrix} & Fe\frac{1}{3} & \\ Mg\frac{5}{9} & & Ca\frac{1}{9}\end{smallmatrix}\right)^2 SiO_4$ as an expression of its composition. In the insoluble part the oxygen ratio of acid and bases is 30·28 : 14·15, and here the presence of more than five per cent. of alumina points to the probable occurrence of a felspar in this portion of the stone. If we assume that the iron oxide, magnesia, and lime,[1] are present as a bronzite, the oxygen ratios of the alumina, alkalies, and residual silica, differ very little from 3 : 1 : 9, or those of oligoclase, soda-lime felspar, in some varieties of which a considerable proportion of the soda is found replaced by potash.

1808.—Red River, Texas.[2]

As Graham[3] has shown that the Lenartó meteoric iron contains 2·85 times its volume of occluded hydrogen, carbonic oxide, and nitrogen, and Mallet (see page 28) has found 3·17 times its volume of hydrogen, carbonic oxide, carbonic acid, and nitrogen occluded in the meteoric iron of Augusta Co., Virginia, it occurred to the author that it might be possible to detect in the gas of these irons the unknown gaseous elements assumed to be present in the solar corona and chromosphere. The investigation was undertaken with the hope that the spectroscope would reveal them, if present, although their small amount or peculiar characters might render their detection by ordinary chemical methods difficult or impossible.

A vacuum tube of the form ordinarily employed in spectroscopic work was attached to a branch of the exhaust tube of a Sprengel pump, and a preliminary examination was made of the lines exhibited by this tube after simple withdrawal of the air. As Plücker and Hittorf[4] have already shown, lines of hydrogen and bands due to carbon make their appearance as soon as the limit of exhaustion has been attained; the author noticed the red hydrogen line when the tension fell to 4 or 5 mm., and other hydrogen lines when a higher degree of rarefaction was attained. Mercury lines, varying in brightness with the temperature of the room, are also to be seen. His investigations were directed to an examination of the gases of the great Texas meteorite, preserved in the Mineral Collection of Yale College, and the meteoric irons of Tazewell Co. and Arva, Hungary (which see). The iron was in very small particles—chips produced by the borer, and the exhaustion was proceeded with without the application of heat. He noticed that the iron gave off a portion of its gas at ordinary temperatures; and when the tension was reduced to 4 mm., $H\alpha$ and $H\beta$ were bright and distinct, and $H\gamma$ visible, while the carbon bands were also distinctly seen. When a gentle heat was applied, the tube, which had hitherto presented the appearance of an

[1] The bronzite of Harzburg, analysed by Streng, contains lime.
[2] A. W. Wright. *Amer. Jour. Sc.* 1875, ix. 294.
[3] T. Graham. *Proc. Royal Soc.*, xv. 502.
[4] J. Plücker and W. Hittorf. *Phil. Transactions*, clv. 1.

ordinary hydrogen tube, underwent a change; the light in the broad portion became a straight, hazy stream, of a dull greenish-white colour, similar to that observed in a tube containing either of the oxides of carbon. When the tube containing the metal was raised to low redness, only a small quantity of gas was given off. Wright did not measure the amount of gas removed by the pump, but has calculated this quantity from an observation of the degree to which 1 cc. of the gas lowered the guage of the instrument. He finds in this way the mixed gases extracted to have occupied 4·75 times the volume of the metal. While this exceeds the quantity which Graham and Mallet noticed in their investigations, the author believes that the whole amount was by no means exhausted, and ascribes the excess to the fact of the metal which he used having been in a fine state of division.

1810.—Brahin, Minsk, Russia.[1]

Two large meteoric masses were found at Brahin in the early part of this century; the dates of their discovery are variously given as 1810 and 1820, and they were first described in 1822. They bear the closest analogy to "the Pallas iron" in structure, and with it belong to the small class of siderolites. The Brahin iron was very imperfectly examined by Laugier in 1823, who confined his analysis to that of the iron. Since that time it has not been investigated except in one respect by Rose, who a few years ago noticed that the olivine was traversed by canals, as the Krasnojarsk olivine is (see page 313, *note*). Rammelsberg, who has recently examined this siderolite, finds the metallic portion to consist of:

Iron = 88·96; Nickel and Cobalt = 11·04. Total = 100.

During the half century which has elapsed since Laugier's time, new and refined methods of analysis have been devised, and Rammelsberg now finds a per-centage of nickel and cobalt more than four times as great as that given by the original observer. The per-centage is close to that found by Berzelius in the metallic portion of the Krasnojarsk siderolite (11·19 per cent.); so that they have a composition closely according with the formula $Ni\ Fe_8$.

The olivine, now analysed for the first time, has the composition:

Silicic acid	37·58
Iron (manganese) protoxide	18·85
Magnesia	43·32
	99·75

These numbers, contrary to expectation, do not agree with those resulting from the analysis of the Pallas olivine; above we have Fe and Mg in the ratio 1:4; in the Pallas olivine about 1:8. It is not a little remarkable, however, that the Brahin olivine has the same composition as that of the Atacama siderolite analysed by Schmid, the iron whereof has been shown by Bunsen to contain Nickel=10·25, and Cobalt = 0·70 (see page 77, *note*).

[1] C. Rammelsberg. *Monatsber. Ak. Wiss. Berlin*, 1870, lxx. 440.

1812, August 5th.—Chantonnay, Dép. de la Vendée, France.[1]

In the winter of 1874 Tschermak published a paper on the structure of the meteorites of Orvinio (see page 222) and Chantonnay, which appear to have many characters in common. Sections of the latter stone, three drawings of which are given in his paper, show it to be made up of chondritic fragments, covered with a dark-coloured crust, and cemented together with a black and in places semi-vitreous material. The fragments are not very abundantly provided with spherules, although large ones are here and there met with. It differs from the chrondrite of the Orvinio meteorite in containing less iron; a section shows olivine, bronzite, a finely fibrous translucent mineral, as well as nickel-iron and magnetic pyrites; the presence of chromite was not recognized. Fine black veins of a mineral traverse the fragments here and there, and are connected with the cementing material. Similar veins are noticed in the meteorites of Lissa, Kakowa, Chateau Renard, Alessandria, and Pultusk; and in the Lissa and Kakowa stones they present the appearance as if the meteorite had originally come in contact with a molten material which had been injected into the clefts of its surface. Reichenbach was of opinion that the black veins were directly and intimately connected with the fused surface; his view, however, is open to question, from the fact that the interior of a meteorite has usually a low temperature when it reaches the earth's surface. Moreover, in the case of the Chantonnay stone, clefts are to be met with into which the black matter of the crust has penetrated to a depth of 6 mm. only, although the cleft remains partly open. The black semi-vitreous magma consists of an entirely opaque mass, enclosing flakes of the silicate, which forms the fragments, as well as occasional spherules.

Although Rammelsberg, who analysed this stone, does not describe the physical characters of the material he operated on, and did not separately examine the fragments and the cementing material, as Tschermak has done in his examination of the Orvinio meteorite, to find that the two constituents have much the same composition, Tschermak points out that the two meteorites have a very similar constitution, differing mainly in the proportion of iron. The characters observed in these two meteorites point to the conclusion that they did not originally possess their present constitution, but that to the disintegration of a solid rock-mass and its subsequent cementation with a semi-vitreous magma their present appearance is due. Although they resemble somewhat the eruptive breccias, they differ from them in that the meteoric cementing material is less homogeneous, and encloses fine flakes of the rock itself. The Chantonnay stone exhibits the fine texture observed in some metamorphosed breccias. The two stones convey to us evidence of changes which must have occurred on the solid surface of some planet that was subsequently reduced to fragments.

[1] G. Tschermak. *Sitzber. Ak. Wiss. Wien*, lxx. November Heft, 1874.

1813, September 10th.—Adare, etc., Co. Limerick, Ireland.[1]

This meteorite, originally investigated by J. Apjohn,[2] has been examined by R. Apjohn, who finds that it contains a trace of vanadium. The date which he assigns to the fall of this stone, 1810, appears to be that of another Irish meteorite, which fell at Mooresfort, Tipperary. The nickel-iron has the composition:

Iron = 85·120; Nickel = 14·275; Cobalt = 0·602; Phosphorus = Trace; = 99·997

and the result of the treatment with acid:

	SiO_2	Al_2O_3	FeO	MnO	CaO	MgO	Na_2O	K_2O	P_2O_5	
A. *Soluble*......	42·91	2·35	16·93	6·26	5·34	24·32	0·29	0·02	——	= 98·42
B. *Insoluble* ...	59·48	3·24	7·94	8·84	4·62	13·17	1·86	0·30	trace	= 99·45

The mineralogical composition of the stone is stated to be:

Nickel-iron	19·07
Chromite	1·75
Magnetic pyrites	6·54
Soluble silicate	35·44
Insoluble silicate	37·07
	99·87

The chromium oxide present as chromite is not mentioned at all in the above analysis. The iron sulphide is probably present as troilite (iron monosulphide), as according to the older analysis the greater part of the sulphur is in the part which is not attracted by the magnet. There the ratio is given as Fe = 3·92, S = 2·04; the per-centages for troilite, using the sulphur as the basis for the calculation, would be Fe = 3·57, S = 2·04; and for magnetic pyrites Fe = 3·12, S = 2·04.

In an obliging letter received from the author he informs me that the amount of vanadium present was too small to allow of a quantitative estimation being made. He believes that in amount it is about one-half that met with in the trap-rocks of Ireland and Italy, which have recently been examined by him. He is inclined to the belief that the vanadium is present as an oxide associated with the chromite, "for we know vanadium occurs in terrestrial chrome iron in comparatively large quantities."

1814.—Lenartó, near Bartfeld, Saros, Hungary.[3]

Boussingault, who some time since found nitrogen in this iron, has recently examined it with the view of determining whether it contains carbon in a state of combination with the metal. His analysis, given below, did not detect the presence of that element in any form.

Iron = 91·50; Nickel = 8·58; Insol. Residue = 0·30; Copper = trace. Total = 100·38.

It was in this meteoric iron, it will be remembered, that Graham made the interesting discovery of the presence of hydrogen condensed

[1] R. Apjohn. *Jour. Chem. Soc.* [2], xii. 104.
[2] J. Apjohn. *Trans. Irish Acad.*, xviii. 17.
[3] J. Boussingault. *Compt. rend.* lxxiv. 1287. *Ann. Chim. et Phys.* xxviii. 124. *Chemical News*, No. 688, 59.—M. Salet, *Revue Scientifique*, 1872, March 9th. *The Academy*, iii. 113.

(occluded) in the substance of the metal. The gas obtained from this iron has been examined spectroscopically by Salet, who communicated his results to the *Société chimique de Paris* on the 1st March, 1872. His researches on the polar aurorae had led him to seek for the yellowish-green ray ($\lambda=557$), but he found only those due to the presence of hydrogen and an oxide of carbon. It must be assumed then that the carbon present in the iron, and which must be very small in quantity, exists there not as carbide of iron, but as occluded carbonic oxide.

1828.—La Caille, near Grasse, Alpes-Maritimes (formerly Dép. du Var), France.[1]

Meunier has submitted the Caille iron to an exhaustive examination. He finds, when etched, that it presents much the same appearances as he noticed in the Charcas iron (see page 320); it consists of kamacite (*chamasite*; E. S. Dana's "Second Appendix to Dana's *System of Mineralogy*," 11) and tänite in much the same proportions. The tänite has a specific gravity of 7·380 (von Reichenbach in another meteoric iron found the number 7·428) and the composition:—

Iron = 85·0; Nickel (cobalt) = 14·0. Total = 99·0.
Iron = 85·0; Nickel (cobalt) = 15·0. Total = 100·0.

numbers which indicate the formula Fe_6Ni.

The kamacite has the specific gravity 7·652, and consists of:

Iron = 91·9; Nickel = 7·0. Total = 98·9.

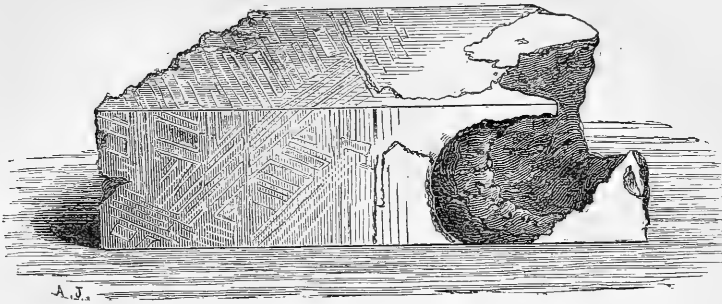
which is an alloy of the formula $Fe_{14}Ni$. The entire iron appears to contain about 80 per cent. of the latter alloy, and Meunier's numbers correspond very closely with those obtained by Rivot, who analysed the metal in the bulk.

The graphite of this iron, found in the residue after treating the metal with hydrochloric acid, has a density of 1·715, and the composition:

Carbon = 97·3; Iron = 2·4; Nickel = trace. Total = 99·7.

The troilite of the Caille iron, after treatment with acid, left a small amount of siliceous residue, which was precisely similar in its physical characters to that found in the Charcas meteorite (see page 319). By the action of heat and oxidizing agents figures were developed which likewise bore the closest resemblance to those developed on the Charcas iron. The accompanying woodcut gives a representation of a block of this iron (actual size) which is in the Paris Collection. It shows the Widmannstättian figures, developed by etching with hydrochloric acid, and the reniform hollows which have been filled with troilite.

[1] S. Meunier. Thèse presentée à la Faculté des Sciences de Paris, 1869. *Recherches sur la composition et la structure des Météorites*, 29, *et seq.* *La Nature*, i. 292.—J. Boussingault. *Compt. rend.* lxxiv. 1287. *Ann. Chim. et Phys.* xxviii. 124.



In an examination of this iron, undertaken with the view of determining the presence of combined carbon, Boussingault found it to be composed of:—

	I.	II.
Iron	89·53	89·73
Nickel	9·76	9·90
Carbon combined	0·12	0·12
Insoluble portion	0·59	0·25
Sulphur	trace	trace
	100·00	100·00

1828, June 4th.—Richmond, Chesterfield Co., Virginia.[1]

This meteorite, the chemical characters of which were studied by Shepard, the physical by G. Rose, has recently been found by Rammelsberg to have the following composition:

Nickel-iron	8·22
Iron Sulphide	4·37
Olivine	45·73
Undecomposed Silicate	41·68
	100·00

The silicates having been separated by treatment with acid and sodium carbonate were found on analysis to have the composition given below:

	SiO_2	Al_2O_3	FeO	MgO	CaO	
A. *Soluble.*	39·40	—	18·21	41·69	0·80	= 100·00
B. *Insoluble.*	53·74	5·32	13·17	22·23	5·54	= 100·00

In the soluble portion the ratio of Fe to Mg is 1 : 4, which shows it to be an olivine identical in composition with that variety of this mineral which has been met with in the siderolites of Brahin and Atacama. The insoluble portion, according to Rammelsberg, is either a bronzite containing lime, or a mixture of that mineral with diopside.

Shepard had found this meteorite to be composed of 6 per cent. of nickel-iron, with some magnetic pyrites, and 90 per cent. of olivine, the residue being howardite and lime phosphate.

1835, July 31st, or August 1st.—Charlotte, Dickson Co., Tennessee.[2]

The iron, which is found disseminated in small particles throughout the mass of many meteoric stones, represents in miniature the

[1] C. Rammelsberg. *Monatsber. Ak. Wiss. Berlin*, 1870, lxx. 440.

[2] J. L. Smith. *Compt. rend.*, 1875, lxxxi. 84.

huge blocks of meteoric iron that from time to time have been met with on many parts of the earth's surface, the record of the fall of which is unknown, their descent having probably taken place at an epoch long anterior to that of their discovery. While the stones enclosing iron have not unfrequently been seen to fall, the descent of purely metallic masses has been rarely witnessed. At present we know of only the following few authentic cases: Agram (1751); Braunau (1847); Victoria West, S. Africa (1862); and Nidigullam, Madras (1870). To these few instances is to be added the one heading this notice, of which a brief account was published by Troost, of Nashville, in 1845.[1] The Tennessee iron fell from a cloudless sky, near several persons who were working in the fields. A horse which was harnessed to a plough close by took fright, and ran round the field, dragging the plough with it.

The iron has remained in the Troost Collection up to the present time, when it passed into the hands of Dr. Lawrence Smith. It is a reniform mass, and has a bright surface like that of soft cast-iron. When etched it exhibits Widmannstättian figures in great perfection, and the author states that in this respect he is acquainted with only three or four irons which rival it. An illustration accompanying his paper, closely resembling the one given by Troost, is a representation of the outer surface, magnified; this is elaborately reticulated, edges of thin laminæ of metal, inclined at angles of 60°, traversing the surface, the edges being separated from each other by an apparently semi-fused slag-like material. The specific gravity of the iron is 7·717, and its composition:

Iron = 91·15; Nickel = 8·01; Cobalt = 0·72; Copper = 0·06. Total = 99·94.

Sulphur is not present, and of phosphorus only a trace was recognized; and the author states that he has never before met with so small a proportion of this element in a meteoric iron. The gas, extracted from this iron by A. W. Wright, who has recently examined the occluded gases of the irons of Texas, Arva, and Tazewell Co., as well as that of the meteorite of West Liberty, Iowa (which see), has nearly twice the volume of the metal operated upon, although this is probably a portion only of that actually present. It is composed of:

Hydrogen = 71·04; Carbonic oxide = 15·03; Carbonic acid = 13·03. Total = 100·00.

A question of no slight interest in regard to the changes which meteoric irons undergo during their passage through the atmosphere is whether their surface becomes fused. From his study of the Tennessee meteorite, Dr. Smith has decided it in the negative. The fact of the delicate reticulated surface having been preserved is a proof that the heat, instead of having been raised to a high temperature on the surface, has quickly been conducted away into the mass of the metal. Had fusion of the superficial layer taken place, the meteorite would have been coated with molten oxide.

The author finds in this fact a confirmation of his theory that the Ovifak masses are not of meteoric origin.

[1] G. Troost. *Amer. Jour. Sc.*, xlix. 336.

1838, July 22nd.—Montlivault, Dép. Loir-et-Cher, France.[1]

Daubrée gives a brief description of this meteorite, which has recently been acquired for the Paris Collection. It has been preserved almost entire, and is roughly shaped like a three-sided pyramid. It is finely granular, has a white colour, and weighs 510 grammes. The ground-mass of the stone, consisting apparently of an intimate mixture of olivine with an augitic mineral, encloses small grains of nickel-iron and magnetic pyrites. The meteorite belongs to the group, now a large one, of meteorites to which the name luceite has been given.

1840.—Szlanicza, Arva, Hungary.[2]

For his investigation by means of the spectroscope of the gases occluded by meteoric iron, Wright examined those from the Red River, Texas, and Tazewell Co., Tennessee (which see).

The amount of carbon present in the former iron was found on chemical examination to be very small; in the latter none was detected. A series of experiments were therefore made with the above iron, which according to Löwe[3] contains a larger amount of carbon. While it was an easy task to remove fragments of the abovementioned irons, great difficulties were experienced in the present case, the metal having nearly the hardness of steel. When the tube containing fragments of this iron was exhausted, and before heat was applied to it, the spectroscope indicated the presence in the "vacuum-tube" of both hydrogen and carbon gases; the lines of the former element were very brilliant, and the first, second, and third bands of the latter, counting from the red end, were visible. The application of a heat hardly sufficient to pain the hand caused an entire change in the appearance of the vacuum-tube; the broad part took a greenish hue, while in the spectroscope the carbon bands shone quite brightly. When the heat was raised to a temperature considerably short of redness, the only change noticed in the spectrum was a greater intensity of the carbon bands; the gas collected at this stage of the operation was found on analysis to consist of hydrogen, carbonic oxide, and carbonic acid, the latter amounting to three or four per cent.

In some experiments on artificial soft iron the author obtained a spectrum in every way similar to that of the meteoric metals; the hydrogen lines, however, did not appear so early, nor were they so bright as in the latter instances.

The iron of this meteorite, which by its great hardness was separated in the state of fine powder, yielded, when heated at different temperatures up to low redness, 44 times its volume of gas. While it seems not improbable that some portion of what has been regarded as occluded gas may have been air, the yield is so unusually large that it suggests the question, May not the more perfect removal

[1] G. A. Daubrée. *Compt. rend.* 1873, 10th Feb. *Der Naturforscher*, 1873, 26th April.

[2] A. W. Wright. *Amer. Jour. Sc.* 1875, ix. 294.

[3] A. Löwe. *Amer. Jour. Sc.* [2], viii. 439.

of the gas from the iron be due to the fine state of division of the metal operated upon? In the case of the Texas and Tazewell irons, where the yield of gas exceeded that obtained from the Lenartó and Augusta Co. irons, the metal was in very small pieces, which would favour a more rapid and complete evolution of the gas; in the last-mentioned instances they were *en bloc.* That iron may under certain conditions, as when deposited by electrolysis, take up nearly two hundred and fifty times its volume, has been shown by the recent researches of Cailletet.[1] An observation recently made has a bearing on this question. While analysing a specimen of silver amalgam, I endeavoured to remove the mercury from a weighed fragment of the mineral by heating the specimen in a hard glass tube, during more than five minutes in the flame of the table blowpipe. The silver immediately fused and remained during that time in a molten state. When cold, the globule of metal was flattened into a plate, and having cut it into strips, and subjected it to a second heating, I succeeded in removing a considerable part of a per cent. of mercury from it.

Wright's researches on the gases of meteoric irons have shown a varying character in the oxygen and nitrogen lines when in the presence of hydrogen, and the near coincidence of two of them with prominent lines in the corona, with the possible coincidence of a third line, which appears to indicate that the characteristic lines in the coronal spectrum are due, not so much to the presence of otherwise unknown elements, as to hydrogen, and the atmospheric gases oxygen and nitrogen.

The observations were made with a spectroscope of six prisms with a repeating prism, giving the dispersion of twelve in all.

(To be continued in our next Number.)

VI.—On the Occurrence of Neocomian Sands with Phosphatic Nodules at Brickhill, Bedfordshire.

By Walter Keeping,
(Of the Woodwardian Museum), Christ's College, Cambridge.

In a traverse through part of Buckinghamshire and Bedfordshire last vacation, with the object of tracing the extent of the Cambridge Greensand, I was informed of some recently opened Coprolite works at Brickhill, near Bletchley. On further inquiry, they proved to be the "red coprolites," a term applied by the workmen to the phosphatic nodules of the Neocomian like those of Potton and Upware (the Cambridge Greensand and Gault nodules being known as the "black coprolites").

The workings are seen on a hill near Great Brickhill, which is about three miles from Bletchley Junction, and the section exposed is about thirty feet deep. The deposit is a rather coarse sand throughout, composed of grains of quartz, lydian stone, and comminuted shells,

[1] L. Cailletet. *L'Institut,* Nouv. Sér. iii. 44.

sometimes hardened by iron oxide or calcium carbonate; the former along lines of oblique lamination, the latter usually in irregular masses, which are rejected as useless. As I saw it, the lower ten feet was of a dull greenish or grey colour, passing in an irregular manner into the redder portions above; but there is no definite divisional line separating the two, the difference in colour being probably due to the oxidation of the iron in the more superficial part.

As at Potton, these sands repose upon the Oxford-clay, the *Gryphea dilatata* being abundant in the clay beneath.

Unlike any other coprolite working known to me, there is no "seam" here, but the phosphatic nodules are scattered through the entire thickness of the section,[1] and they are separated by sifting the whole of the thirty feet of sands, except where they are too much hardened by cementing substances. Thus separated, the coprolites are washed in revolving perforated cylinders, and any pebbles of quartz, chert, lydian stone, etc., are picked out when the material is ready for grinding. The whole process is the same as that carried on at Potton in Bedfordshire and Upware near Cambridge.

From Palæontological evidence, we have long believed the Upware deposit (which has already been described in the pages of this MAGAZINE[2]) to be the representative of, if not continuous with, the Farringdon Sponge-bed. Now Brickhill is nearly equally distant from Upware and Farringdon; here then is the spot to settle the question of their relation.

The phosphatic nodules of Upware occur in the Neocomian Sands in three seams, which are irregular and sometimes run together,[3] and in the Rushmoor Brickyard,[4] a few miles from Brickhill, the "coprolites" may be seen similarly collected into a bed from four to seven feet thick, resting on the Oxford-clay. At Farringdon coprolites are found scattered through the sands, especially towards the base.

But few fossils are to be seen among the prepared coprolites, and these are mostly phosphatised casts in a much worn condition, so that a glance at the heap would lead one to observe with the Rev. P. B. Brodie,[5] when speaking of the Potton bed, that "every organism in this phosphatic bed is evidently extraneous." *Ammonites biplex* is always the conspicuous fossil in this condition, together with *Cardium striatulum, Arca,* and *Myacites,* all of which I found at Brickhill.

But on breaking open the hard masses cemented by the carbonate of lime, and also in a small patch of the section where calcareous matter remained, the natives of the bed were themselves found, still with their shells well preserved, and in general appearance closely resembling those of Upware. The following is a list of them.[6]

[1] In the lower part they are more numerous and blacker.
[2] J. F. Walker, GEOL. MAG. 1867, Vol. IV. p. 309.
[3] Walker, op. cit. p. 310.
[4] I was informed that about four years ago they bored for coal in this yard!
[5] GEOL. MAG. 1866, Vol. III. p. 153.
[6] Mr. J. F. Walker has kindly examined and confirmed my identifications of those species described by him in the GEOL. MAG. Vol. IV. p. 454; Vol. V. p. 399.

Those marked U, are known to occur at Upware, near Cambridge; F, at Farringdon.

Terebratula prælonga (Sow.), U, F.
„ *depressa* (Lam.), U, F.
„ *Moutoniana* (d'Orb.), U, F, small and striated variety.
„ *microtrema* (Walker), U.
„ *sella*, var. *Tornasensis* (d'Arch.), U, F.
„ *extensa* (Meyer), U.
„ *Seeleyi* (Walker), U.
Waldheimia Wanklyni (Walker), var. *elliptica*, U.
„ *pseudojurensis* [1] (Leym.), U, F.
Terebratella oblonga (Sow.), F.
Terebratulina striata (Wahl.), var. *elongata* (Dav.).[2]
Rhynchonella Cantabridgiensis (Dav.), U.
„ *Upwarensis* (Dav.), U.
„ *antedichotoma* (Buv.), U, F.
„ *depressa* (Sow.), U. F.
„ *latissima* (Sow.), F.
Ostrea macroptera (Sow.), U, F.
Lima Farringdonensis (Sharpe), F.
„ *Dupiniana* (d' Orb.), (?).
Cidaris Farringdonensis (Wright), ? F.

This list is extremely interesting, as being intermediate between the two remarkable and isolated faunas of Upware and Farringdon;[3] for of the twenty species enumerated, no less than fourteen are common to Upware, twelve occur at Farringdon, and seven are found in all three localities. *Terebratula microtrema, T. Seeleyi, Waldheimia Wanklyni, Rhynchonella Cantabridgiensis*, and *R. Upwarensis* were hitherto unknown out of the Upware deposit.

It may be found necessary to separate the specimens which I have named *T. Moutoniana* as a variety of that species, differing as it does from the type in being smaller and distinctly striated.[4] We may call it *Terebratula Moutoniana*, var. *Brickhillensis*.

It is conspicuous that the sponges so remarkably developed at Upware and Farringdon are absent from this list; this is, I think, accounted for by the want of calcium carbonate, such as might have been supplied by the Coral-rag of Farringdon and the Coral-reef of Upware. In the sands of both these localities fragments of the Coral Limestone are abundant; and I observed, when the fine series from Upware was being collected for the Woodwardian Museum, that nearly all the sponges were found close to the Coral-reef. Lately, since the workings have been removed only 200 or 300 yards further off, where the bed rests on the Kimmeridge-clay, sponges occur but rarely.[5]

The coprolites at Brickhill are of the same type as those of

[1] Mr. Walker informs me that this species has lately been also met with at Folkestone.

[2] I am indebted to Mr. Davidson for this identification. He informs me that "the same variety occurs in the Bargate stone (Upper Neocomian) of Guildford and Godalming in Sussex."

[3] I hope to be able to add to this list as the workings go on, the result of which may prove worthy of another communication to this MAGAZINE.

[4] Faint striæ have been observed on some of the Upware specimens. See Mr. J. F. Walker's article in GEOL. MAG. 1868, Vol. V. p. 403, Plates XVIII. and XIX.

[5] My father has since obtained for the Woodwardian Museum a few sponges from Brickhill.

Upware and Potton, viz. the light yellow varying to dark brown, almost to the black type, much worn *before they reach the mill,*[1] and perforated by lithophagous mollusca and annelids. They contain (at Potton) about 48·51 per cent. of phosphate of lime.[2]

In conclusion, I may remark on the wide distribution of these Neocomian "coprolites." They occur at Farringdon, Brickhill, Rushmoor, Potton, Upware, and I have lately found them in the Upper Neocomian Sands of Lincolnshire. In all these places they are of the same type, much worn and drilled, and abounding with *Ammonites biplex* and other Kimmeridge-clay forms. This fact of the Kimmeridge-clay origin of so many of these "coprolites" is of importance in considering the origin of the phosphatic matter; for since we do not find the fossils in this phosphatised condition abundantly in the Kimmeridge-clay, while they are invariably so over a wide extent of country as derivative fossils in the Neocomian, we may infer that the phosphate was obtained in the latter period; in other words, as suggested by Mr. Walker,[3] that the coprolites are nodules derived from the Kimmeridge-clay, which have been "soaked" with phosphates obtained by the decomposition of animal and vegetable matter in a shallow sea,[4] with, perhaps, some replacement of the phosphate of lime for carbonate of lime.

I may observe also that at Potton fossils in this eroded condition occur of the Portland and Wealden ages—notably the *Endogenites erosus* of the Weald—indicating, as I believe, the former extension of these deposits near, if not quite up, to this locality.[5] Further north, at Upware, *Endogenites erosa* has not, to my knowledge, been found, and the Dinosaurian remains are much less frequent; so that the northern limit of the Wealden may reasonably be fixed at some place not far from Potton.[6]

REVIEWS.

I.—The Past and Future of Geology. An Inaugural Lecture given by Joseph Prestwich, M.A., F.R.S., F.G.S., etc., Professor of Geology in the University of Oxford, January 29, 1875. pp. 48, with four illustrations. (London: Macmillans.)

MR. PRESTWICH, after paying a just compliment to Oxford by noting how much the infancy of modern Geological Science was indebted to the labours and discoveries of Kidd and Buckland,

[1] The eroded appearance of the Cambridge coprolites has frequently, and to a great extent incorrectly, been referred to the trituration produced by washing in the mills.

[2] Vide analysis by Dr. Voelcker, Geol. Mag. 1866, Vol. III. p. 154.

[3] Ann. Nat. Hist. Nov. 1866.

[4] This theory has no reference to the nodules of the Gault and Cambridge Greensand, which are far too pure for such an origin.

[5] Professor Morris has already (Geol. Mag. Vol. IV. p. 459) from similar evidence stated his conviction that the Wealden beds were present over the neighbourhood of Aylesbury.

[6] M. J. Harris Hall, of St. John's College, informs me that he found coprolites scattered over this hill at Brickhill about two years ago. The result of his inquiry into the Potton and Upware deposits (Sedgwick Prize Essay) will be published very soon.

enters on the consideration of the various cosmical hypotheses as to the origin of our earth, and probably of the other planets, in the condensation of nebular matter. In this he brings forward the yet unpublished and perhaps uncompleted views of Mr. Norman Lockyer, communicated by the latter to Mr. Prestwich, suggesting, from the analogy of the apparent solar constitution, that our globe in its nebular condition had its materials arranged in zones of different densities, the densest of course being innermost—a notion which Mr. Lockyer and Mr. Prestwich both think to be supported by the existing order of the materials constituting the earth, the metalloids forming the outer zones, succeeded by the denser substances, such as the metals, in the interior; granite and other acidic rocks being considered the chief substance of the earliest outer crust, underlaid by the more basic rocks, basalts, magnesites and ferruginous rocks in the first instance, and further towards the centre by the metallic bases. This is a bold speculation, which we will not further remark upon, but leave it as a nut to be cracked by other cosmical geologists.

Mr. Prestwich then proceeds from these highly speculative views to the more direct questions of geology proper, namely, Stratigraphy and Palæontology. He gives several ingenious diagram-illustrations of the proportionate occurrence of different species of organisms in the successive known strata. These must, however, be seen and carefully studied, as it would be impossible to explain them fully, unless we could introduce illustrations of them here.

Mr. Prestwich then comes to what he calls the more especial ground of the geologist (p. 30), namely, "the various chemical and physical questions connected with inorganic matter," in other words, "the great mechanical phenomena exhibited on the surface of the globe,"—the first question being whether these phenomena are most expressive of "energy" or of "*time;*" in other words, the old dispute between the Cataclysmic and Uniformitarian theories.

Upon this point Mr. Prestwich ranges himself rather with the former than the latter. Admitting the enormous and scarcely conceivable periods of time with which geology has to deal, Mr. Prestwich deduces from this not that the minor phenomena which come within the range of our limited experience may, by their multiplication in the course of these countless ages, be made to account for all the larger past changes of which we have evidence, but, on the contrary, that in the vast extent of previous time there is ample room for the possible occurrence of paroxysmal events infinitely exceeding in energy any with which our petty experience has made us acquainted; and here he suggests the rather ingenious argument that, as the recognition of a glacial period has led to the admission of an early greater intensity of cold, so the evidence of a greater intensity of heat should by analogy be equally admissible (p. 36, note). From this Mr. Prestwich naturally proceeds to consider the hypothesis of central heat, and of the presumed contraction of the earth on cooling, "accompanied by a shrinking (? crumpling) of the crust, to which the trough of oceans, the elevation of continents, the protrusion of mountain chains, and the faulting of strata, are to be attributed." He finds in these phenomena an argument for their explanation rather by sudden and excessively violent shocks at very distant intervals than by minor and more frequent oscillatory movements. We cannot in this brief notice enter on a criticism of this argument, or we might, we think, show that it contains a fallacy. We join, however, heartily in the concluding passage of this portion of the address: "Of these forces it is as difficult for us to realize the intensity as it is to fathom the immensity of space. These are among the questions of the future." (p. 40.)

Presuming, however, the earth to have arrived at present at a state of comparative "quiescence," Mr. Prestwich suggests that the glacial period through which the earth has recently passed, owing to whatever cause, anticipated in some degree the ultimate refrigeration of the globe through the radiation of heat into space; and by retarding this process has tended to produce that "period of stable equilibrium" which now obtains, and "which now renders it so fit and suitable for the habitation of civilized man;" and thus "impresses the author with the belief of great purpose and all-wise design." (p. 48.)

II.—Rudiments of Geology. By Samuel Sharp, F.S.A., F.G.S. (Stanford, London, 1875.)

THE object of this book is to give, in a condensed and useful form, an abstract of the most noticeable points in geological research. It is, in fact, rather a series of brief notes of lectures, than a treatise on Geology, and its very size, for it runs into little more than a hundred pages, precludes the possibility of the author's doing more than indicating the salient facts and theories of the science.

This has been satisfactorily attempted; and the arrangement is well adapted to the wants of students who seek for much information in a small space.

The First Part deals essentially with Definitions, a separate paragraph being devoted to each; these are both word-derivations, and, in many instances, explanatory notes of the matter in hand; and are of considerable value.

For example, paragraph 15, which relates to "the processes by which sedimentary strata have been formed at the bottom of rivers, lakes, estuaries, and seas," does not confine itself to a brief statement that Denudation (marine, sub-aerial, or glacial) was the chief cause, but proceeds to describe the process, and to give numerous examples of the action of these several agents.

There is, however, a tendency in some instances to popularize information and simplify terms in a hasty and inaccurate manner. This may often lead to false impressions. Thus granite is spoken of as "the original foundation and source of all rocks," which is certainly open to question. Again, some of the derivations of technical words are careless; for *stratum* is not a "covering" body, *onta* are not necessarily "existing" beings, *meta* is not "change," and, if the

Alpine streams carry down an "incalculable" quantity of material, geologists may as well give up the attempt to be exact in their calculations. The same want of care is evidenced in other pages; thus we may remark, in the enumeration of the characteristic fossils of the *Stonesfield Slate,* Mr. Sharp notices the occurrence of "the wing-cases of Beetles, a beautiful wing of a Butterfly, and many *insects,*" which sentence requires the addition of "other" before the final noun to be correct. So also at page 48, "*Mollusca* are less plentiful than Cephalopoda"! Still these slight inaccuracies are of little importance, and do not greatly militate against the undoubted value of the work.

Part II., which deals with the Stratigraphical and Palæontological data, is prefaced by a well-arranged table, giving, in addition to the customary list of formations, the maximum thickness of each set of beds. Then follows an account of the various divisions and subdivisions of these formations, useful references being made in each case to the lithological and palæontological characteristics of each, sufficient to give a good general idea of the nature of the groups of strata; and, though space admits neither of illustration nor details, the brief account of the most remarkable fossils is clear, though the natural-history knowledge exhibited is by no means perfect.

The more important groups of the animal and vegetable life of the several epochs are alone referred to; and the most important lithological features and fossils, which would lead to the general identification of the groups, are enumerated and defined, so as to admit of ready appreciation by an inexperienced student.

Great care is shown in the description of the Oolites, and, brief as it necessarily is, it is full of value; the range, for instance, of the more or less marine beds of the "Stonesfield Slate" through Northamptonshire and Lincolnshire, possibly to Scarborough, where it "is probably ultimately represented by the Upper Plant Shale," being clearly explained by the successive alterations in the Palæontological peculiarities of the series of beds. In fact, the author seems to be essentially an Oolitic Geologist, treating the older beds, from the Lias downwards, and the upper beds from the Purbeck upwards, chiefly in the light of Lyell's "Student's Manual" and other elementary works and compilations.

The book closes with a short description of the first-known appearance of Man upon the earth; flint implements being found associated with bones of the Elephant, Cave-Bear, etc., but not with human bones; and the history of this most interesting branch of modern geological research is shortly told.

Mr. Sharp's "Rudiments of Geology" will be a useful book for geological students of all classes. To the more advanced reader it furnishes a handy précis of the chief points in the branch of science he pursues; for the beginner it provides the scaffolding wherewith he may arrange his future studies and build up his knowledge.

C. Cooper King.

III.—"The Geology and Races of India." (Edinburgh Review, April 1875.)

An article in the April number of "*The Edinburgh*" treats at some length of the Geology of India, and its connexion with the races of that country. With the latter part of the subject it is not necessary to deal here, though the affinity between Race and Geology may be thought somewhat loosely and discursively treated as an attribute of scenic and agrarian influences; the reader being referred to Buckle's "History of Civilization" for the laws which regulate the influence of soil and climate upon the creation of wealth, civilization and luxury: while it is difficult to gather from the article itself the slender links between intellectual development of national character and the "stupendous convulsion of the Himalaya," the derivation of Régur, the existence of concealed coalbeds, or the presence of "great trappean effusions."

The writer's descriptions of the Geology of India are however too startling to pass altogether unnoticed when advanced in the pages of such a journal as the *Edinburgh Review*; nor would it be fair to authors upon Indian geology to allow him to claim for strangely mingled misrepresentations that they are given "as detailed by skilful observers."

These descriptions being taken professedly from "amateur authors"—but largely, one might imagine, from Dr. Carter's Summary and Mr. H. Blanford's recently published excellent little work on the Physical Geography of India—it is to be regretted that the writer of the article seems to have assumed the equally "admirable accuracy" of all, and, relying upon this, to have failed in discrimination, while committing himself to statements at variance with facts, familiar to those whose acquaintance with the subject is not altogether circumscribed, or whose desire to increase this knowledge might be stimulated by a paper in an ably-conducted journal.

It is also matter for much regret that, without wading through the whole of the amateur literature of the subject noticed by the writer, besides all the Government publications, no means exist whereby a more ample knowledge of the general features of Indian Geology can be acquired than may be gathered from the chapters by Mr. Henry Blanford—once an officer of the Indian Survey, and now Chief of the Indian Meteorological Department. It has been suggested that the Indian Geological Survey has now sufficiently progressed to enable it to furnish some approximately accurate map and summary of the geology of the whole country. Nothing comprehensive in this form has appeared as yet, but it is evident from the article in question that such a publication is needed; and this could hardly be more competently edited than by the veteran Chief of the Survey, with his long experience, if leisure could be found among his other pressing labours. As it is, the science itself is progressive, and ample time has passed since some of the amateur papers were written to have placed them behind the age.

This however will not excuse the writer of the article referred to for want of acquaintance with some of his own sources of information, when we find it asserted that the oldest rocks of the Himalayas are not of greater antiquity than the Eocene period (p. 332), though this is directly contradicted in a quotation at p. 334, and the late Dr. Stoliczka, Major Godwin-Austen, etc., have recorded their discoveries of Silurian, Carboniferous, Triassic, and other fossils in the Himalayan ranges. Again, he speaks freely of the Palæozoic rocks of Central India, large tracts of which contain no known fossils older than a presumably Jurassic or Cretaceous period, while other enormous spaces are occupied either by crystalline rocks or by layers of bedded trap forming whole ranges of mountains or plateaux like the Deccan, containing, but rarely, in intercalated strata, fossils of Tertiary age (!). Nor is he altogether happy in his conception of a skeleton series of Palæozoic ranges filled in between by deposits of various following ages, *resulting from enormous volcanic action* (!); the upheaval, contortion, and twisting of the plutonic rocks being attributed to "eruptive powers"—while the Cambrian and Silurian series of Central India (!) are mentioned, but we are not told where they may be found, or on what evidence their assumed age is based.

After this an imaginary and imposing volcanic upheaval of the Deccan is spoken of as pre-Miocene, while above certain coarse marine formations of that age there is a newer great Trappean "effusion" referred to, the real existence of which would be even more difficult to prove than the production therefrom (p. 333) of recent Régur and Kunkur or Travertine, or the eruption of felspathic traps of Oolitic age through the Régur of the Carnatic (!) (p. 336).

However far a careless writer might be excused for conveying rather mixed ideas of a subject he was unacquainted with, derived from many sources of differing degrees of accuracy, or perhaps in some cases of inaccuracy, there can be no apology for the inconsecutive and contrary assertions,—in one place that the rocks of the peninsula are intensely disturbed, and in another that the beds south of the Ganges Valley are not in any way contorted or crushed (!). It will be new to any one slightly acquainted with Indian geology to learn "that the geology of the Punjáb is wholly Tertiary and Alluvial," and that "all indications of Primary or Palæozoic rocks are entirely absent"—it having been recorded long ago in the publications of the Geological Society of London (not to mention Indian authorities) that the great Salt Range of that district contains highly fossiliferous Carboniferous limestones and other pre-Tertiary formations. The old error of the province of Kutch being "remarkable for its craters and other evidences of recent volcanic action," is repeated, and a partial upheaval from the sea is stated for the "Runn," although tolerably recent information upon these points is available in a published form. The economic subjects of Indian coal and iron are noticed, the first in some detail; but nothing is said of the great salt deposits of the north.

Discrepancies as gross as these throughout the geological portion of the article leave the impression that the writer was either feebly acquainted with geological subjects, or has most imperfectly collected the materials of which his paper is made up, and we would recommend a reader interested in the matter to turn instead for information to Mr. H. Blanford's little book and to the geological chapters published, or in course of publication, in the Government of India's Gazetteers for each of the Presidencies, wherein condensed accounts of the local geological features will be found. W.

REPORTS AND PROCEEDINGS.

Geological Society of London.—May 26th, 1875.—John Evans, Esq., V.P.R.S., President, in the Chair.—The following communications were read:—

1. "On some Peculiarities in the Microscopic Structure of Felspars." By Frank Rutley, Esq., F.G.S.

The observations recorded in this paper related mainly to some exceptional features in the striation of felspars from various localities, involving a consideration of the extent to which dependence may be placed on the discrimination of monoclinic and triclinic felspars by the methods usually recognized in ordinary microscopic research. Some other peculiar structural features were likewise noticed, and the effects which might be produced on polarized light by the overlap of twin lamellæ in thin sections of felspars, when cut obliquely to the planes of twinning, were also considered.

The paper terminated with a list of conclusions deduced from the observations recorded. These conclusions mostly related to matters of detail; but the general inference drawn by the author was that the present method of discriminating between monoclinic and triclinic felspars by ordinary microscopic examination answers sufficiently well for general purposes, although it is often inadequate for the determination of doubtful examples, and that such examples are of more frequent occurrence than one would at first be led to suspect.

2. "On the Lias about Radstock." By Ralph Tate, Esq., A.L.S., F.G.S.

In this paper the author described several sections in the Lias of the neighbourhood of Radstock in Somersetshire, with special reference to their palæontological contents, and to the question of the division of the Lias into zones in accordance with the species of Ammonites occurring in different parts of the series. He maintained that although the Lower Lias in this district only attains a thickness of 24 feet, this is due to poverty of sediment; and that whilst by this means the zones are compressed, and the species of Ammonites brought almost into juxtaposition, the succession of Ammonite-life is as regular in the Radstock Lias as in the most typical districts. Much of the opposition to the doctrine of zoological zones he ascribed to erroneous discrimination of species. The paper included tables of sections and lists of fossils, with the arguments founded upon them, in support of the above opinion. A few new species were described under the names of *Trochus solitarius*, *Cryptœna affinis*, *Cardita consimilis*, and *Cardinia rugulosa*.

3. "On the Axis of a Dinosaur from the Wealden of Brook, in the Isle of Wight; probably referable to *Iguanodon.*" By Prof. H. G. Seeley, F.L.S., F.G.S.

This perfect specimen, preserved in the Woodwardian Museum of the University of Cambridge, is 3½ inches long and 3¼ inches high. The odontoid process is anchylosed to the axis, and projects forward as in the axis of birds, so as to articulate with the occipital condyle of the skull. The pre- and postzygapophyses are situated much as in birds; as are the two ovate pedicles, on the anterior part of the side of the vertebra to which the cervical rib was articulated. But posteriorly the articular surface for the third cervical vertebra is transversely ovate and slightly concave. The neural spine is compressed from side to side, more so in front than behind. Among mammals, the nearest resemblance to this kind of axis is seen similarly in the whale; and among reptiles the crocodile has a two-headed rib; but the other characters are more like those of *Hatteria,* which the author regarded as a near ally of the Crocodilia and Chelonia, and as wrongly united with the Lacertilia.

4. "On an Ornithosaurian from the Purbeck Limestone of Langton, near Swanage (*Doratorhynchus validus*)." By Prof. H. G. Seeley, F.L.S., F.G.S.

The author obtained these specimens (a lower jaw and a vertebra) in 1868, and described them in the "Index to the Secondary Reptilia, etc. in the Woodwardian Museum," in 1869, as *Pterodactylus macrurus.* He now believed that the Ornithosaurian vertebræ from the Cambridge Greensand, which have been regarded as caudal, are really cervical, and therefore that the analogy on which this vertebra was determined to be caudal cannot be sustained; he proposed to adopt for his species Prof. Owen's specific name *validus*, given in 1870 to a phalange of the wing finger from the same deposit. The vertebra is 5 inches long, relatively less expanded at the ends than similar vertebræ from the Cambridge Greensand, has strong zygapophysial processes, and a minute pneumatic foramen.

The lower jaw, as preserved, is 12¼ inches long. The symphysis extends for 5 inches, and is about ⅛ of an inch deep, and divided into two parts by a deep median groove. The teeth extended for 8 inches along the jaw, and about 7 or 8 occurred in the space of an inch. They were directed outward in front, and became vertical behind. Where the rami are fractured behind, they measure 2¼ inches from side to side.

OBITUARY.

SIR WILLIAM EDMOND LOGAN.

LL.D., F.R.S., F.G S., V.P. Nat. Hist. Soc. Montreal.

Yet another leading man has passed away—one whose name has become familiar to geologists during fifty years of the most vigorous growth of our science, and one whose labours and researches have contributed in no small degree towards that development and progress of ideas by which geology at the present day is characterized.

William Edmond Logan (who was of Scottish parentage) was born in Montreal in 1798. His education, commenced in Canada, was continued at the High School and in the University of Edinburgh. He soon displayed a love for geological pursuits, and commenced in South Wales carefully to study the structure of the Coal-field of that region, and to map the outcrop of its numerous Coal-seams, depicting their faults and most minute details on the One-inch Sheet of the Ordnance Survey. This admirable work he generously handed over to Sir Henry de la Beche when he began the Survey of that district, and on the early Sheets of the Government Geological Maps for South Wales the name of W. E. Logan appears with those of De la Beche, Ramsay, Phillips, and Aveline.

During this time Logan worked on the staff of the Survey as a volunteer, and among other valuable services rendered he introduced the practice of drawing horizontal sections on a true scale of six inches to a mile, which afterwards served as models for the large sections of the Survey.

At this early part of his career Logan made a most important observation on the origin of coal, then but little understood. He pointed out that each coal-seam rests on an "underclay" or "fireclay," in which rootlets of *Stigmaria* branch freely in all directions. This association of coal and *Stigmaria*-clay he found to be so constant that he was led to the conclusion that the clay represented the ancient soil or mud in which the *Stigmaria* grew, and that the coal was the result of the accumulated growth and decay of the matted vegetation which had once lived upon that soil. Looking back, after a lapse of forty years, we are astonished at the brilliance of Logan's early deduction, which served to throw so clear a light upon the nature and origin of coal, and entitles its author to our highest esteem as a most careful and accurate observer.

In 1841 Mr. Logan went to America, and examined the coal-fields of Pennsylvania and Nova-Scotia, where he also made some original observations. In the winter of 1841-42 he devoted himself to watching the behaviour of ice as a geological agent on the great Canadian rivers. The result of his studies was communicated by Logan in person to the Geological Society of London in the spring of 1842.

About this time (1842) there arose in Canada a strong desire to know something more about the mineral resources of the Colony, and the Legislature having voted £1,500 for a Geological Survey, the Canadian Government consulted the Home Office as to a suitable person to undertake the task, mentioning the name of Mr. Logan, and inquiring in what estimation he was held in England by scientific men. Murchison was at that time President of the Geological Society, and, being appealed to, he warmly recommended Logan, as did also his old friend De la Beche. From his appointment in 1843 Logan's whole energies were given to the task assigned to him, and to his devotion and untiring energy must be attributed the fact that he never allowed the difficulties of his task to overpower him, although beset on all sides with obstacles sufficient to have disheartened men of less determination and ability. The country over which his Survey extended was frequently obscured by dense vegetation. There was no Ordnance Map to use. The

Government, moreover, only acted on impulse, and soon were ready to abandon a Survey which had only been sanctioned by them in a fit of patriotic fervour. Through all these obstacles Logan's tact and perseverance enabled him to steer his bark, and finally to gain the haven of popularity, while success crowned his efforts in the field. Year by year his annual reports were presented to the Canadian Parliament, accompanied by admirable Geological Maps, and it is in these official reports that the chief work of his life is embodied.

He was fortunate in securing excellent assistants in his field work; men whose names are well known to geologists: Alexander Murray (now Director of the Survey of Newfoundland), James Richardson, and in later years Robert Bell, and others. For mineralogical and chemical examination of rocks he secured the services of Dr. T. Sterry Hunt; while for the palæontological determination of the fossils he obtained the aid of Mr. E. Billings. Perhaps the best proof of the benefits conferred by the Survey upon Canada is furnished by the firm footing and liberal support which it now obtains from the Provincial Legislature. The Survey has its Museum and a Laboratory, where the minerals, rocks and fossils of the country are examined and illustrated with especial reference to the industrial resources of the country. By such methods alone can scientific men hope to succeed in securing the hearty cooperation of Colonial Governments. All young States require to be shown some commercial advantage to be derived from geological and other investigations; and in proportion to the success with which this aspect of the subject is put before them, so will be the support given to such scientific undertakings.

After the Paris Exhibition of 1855, at which the mineral productions of Canada had been so successfully exhibited by him, the honour of knighthood was conferred upon Sir William Logan in recognition of his long and unwearied exertions in carrying out this important task. He devoted himself with equal energy to the interests of the Colony at the International Exhibition of 1862. The generalized summary of the labours of the Survey of Canada, during the first twenty years of its existence, published in 1863, contains the gist of his work as well as a luminous account of all that was then known of the geology and mineral wealth of the Province.

Finding his duties too heavy for his advancing years and failing health, Sir William resigned his appointment in 1869, and was succeeded by Mr. A. R. C. Selwyn, formerly of the Geological Survey of Great Britain, and afterwards Director of the Survey of Victoria.

Sir William Logan gave 20,000 dollars towards the endowment of a Chair of Geology in M'Gill's College, Montreal, and up to the last his interest in his favourite science was unabated.

Well has Prof. Geikie observed: "He has done a great work in his time, and has left a name and an example to be cherished among the honoured possessions of Geology." [1]

[1] *Nature*, July 1st, 1875, to which we are indebted for the main facts and most of the statements contained in this notice.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. II.

No. IX.—SEPTEMBER, 1875.

ORIGINAL ARTICLES.

I.—Short Sketch of the Geology of the North of Norway.

By Karl Pettersen.

LEOPOLD VON BUCH, who in the beginning of this century travelled through Norway as far as the North Cape, was the first who wrote about the geology of the northern part of the country (Reise durch Norwegen und Lapland, Berlin, 1810). Some years later the natural conditions of the country were examined by Vargas Bedemar. On this voyage he went as far as Varanger, and has recorded the result of his inquiries in his work "Reise nach dem hohen Norden, Frankfurth-a.-Main, 1819." Furthermore R. Everest, who travelled through Norway to the North Cape in the years between 1825 and 1830, has collected various notices on the mountain structure of the countries in his work entitled "Journey through Norway."

If we consider the vast tract which these men of science had to go over, and the short time they had at their disposal for this purpose, it will be evident that we cannot expect to find in their works complete surveys, but only more or less scattered remarks on the geological structure of the country.

In the years 1827 and 1828 Keilhau had occasion to make more comprehensive investigations in the northern parts of the country, and he succeeded also in giving the first hints for a separation of the principal groups which form the mountainous ground of these regions.

Of course Keilhau never intended to give anything more than preliminary hints. If one takes into consideration that

the area of Finmark is	790	geographical square miles	=	43,480	square kilom.
,, Tromsó "Amt"	412	,, ,,	=	22,710	,,
,, Nordlands "Amt"	687	,, ,,	=	37,820	,,
together	1889	,, ,,	=	104,010	,,

it will be clear that a man, in the course of the summer months of a couple of years, will only be able to go over so vast an extent of country superficially. Moreover, the land is thinly populated; the actual inland area is for the greater part barren; and the "Amts" of Tromsó and Nordland especially form an extremely wild mountain land, frequently intersected by deep fjords, valleys and gorges. Scientific journeys are therefore in these parts always connected with great difficulties.

Keilhau has given the result of his inquiries in his well-known work: "Gœa norvegica, 2 volumes, Christiania, 1844."

More connected geological examinations of these countries were commenced in 1865, and have been continued, but are still far from being concluded. During this time Mr. Tellef Dahll has gone over East Finmark and the inland of West Finmark, and the author of these pages over the coast-land of West Finmark, the whole of Tromsó Amt, and the greater part of Lofoten and Vesteraalen in Nordlands Amt.

A more detailed description of the course and results of the investigations will be found in the following treatises:

Tellef Dahll. On the Geology of Finmarken. Christiania Scientific Society, 1867, pp. 213—222.

Karl Pettersen. Geological Profile from the Boundary of the State over Lyngen to Kvaló. Chr. S. S. 1867, pp. 155—158.

" Profile through the Bed of the Reisen-elv over Uló and Kaagen. Chr. S. S. 1868, pp. 316—321.

" Geological Investigations in the Tromsó District. The Royal Norwegian Scientific Society's Writings, vol. v. pp. 113—240. Trondhjem, 1868.

" Geological Investigations in Tromsó Amt II. R. N. S. S.'s Writings, vol. vi. pp. 41—165. Trondhjem, 1870.

" On the Elevation of Tromsó Amt over the Level of the Sea in the Glacial and Postglacial Age. R. N. S. S.'s Writings, vol. vi. pp. 166—189. Trondhjem, 1870.

" Geological Investigations in Tromsó Amt III. On the Formations of Quaternary Age. R. N. S. S.'s Writings, vol. vii. pp. 103—176. Trondhjem, 1872.

" Tromsó Amts Orology. R. N. S. S.'s Writings, vol. vii. pp. 181—240. Trondhjem, 1872.

" Geological Investigations in Tromsó Amt IV. R. N. S. S.'s Writings, vol. vii. pp. 260—444. Trondhjem, 1874.

" On the Kind of Rock to be found within the Amts of Tromsó and Finmarken. The Geological Society's Discussions in Stockholm, 1874, vol. i. pp. 274—281.

" Anorthite-Gabbro in Seiland, West Finmarken. G. S. D. in Stockholm, vol. ii. no. 4. 1874.

" Arctis—a Contribution to throw Light on the Distribution of Sea Land and in the European Glacial Age. G. S. D. in Stockholm, vol. ii. no. 5, pp. 2—16. 1874.

" On the Occurrence of Elæolite in West Finmarken. G. S. D. in Stockholm, 1874, vol. ii. pp. 220—222.

" Natural Formations of Tunnels and Caves in the Coast-line of West Finmarken. G. S. D. in Stockholm, 1875, vol. ii.

" The Gneissoid Granite Formations along the Coast-line of the North of Norway. G. S. D. in Stockholm, 1875, vol. ii. no. 11. pp. 450-468.

In the following pages we shall try to give a concise view of the results gained through the researches instituted up to the present time.

In the districts (Amts) of Finmark and Tromsó, and in the shrieval districts (Fogderier) of Lofoten and Vesteraalen in the district (Amt) of Nordland, there occur from below upward the following stratified groups:

I. The primitive rock.—This appears as narrow or wider stripes in the coast-tract Island-group from Mageró towards the north, to the termination of Lofoten in the south. It forms moreover the northern part of the peninsula which projects between Alten and

Porsanger and the greater part of the high and wild peninsula which extends from Langfjord and Alteidet westward in the direction of Loppen.

In the inland area of the district (Amt) of Tromsó the primitive rock appears in several places, but always in narrower stripes.

The masses of the strata are formed of grey and red gneiss, hornblende gneiss and hornblende slate, hard micaceous schist, mild shining mica-slate and quartzitic slate. Also layers of chloritic slate may be found alternating with the same. The strike goes usually in the direction of north and south, with deviations sometimes on the one side and sometimes on the other. The dip is often considerable, sometimes even vertical, but in other places it is more nearly horizontal. The dip is to the east or to the west, or sinuous. In some places where the dip is great, such strong sinuosities may repeatedly occur in a longitudinal extent of some few hundred mètres.

From the regular north and south direction of the strike there may occur in some places strong local deviations, even changing to an east and westerly direction, in large connected tracts.

With this widely extended gneiss section there are connected large masses of granite, gneissoid granite and granitoid gneiss forming the chief part of the great Island-group of the coast-tract. The connexion between the purer gneiss and the granitic rock is such that, in spite of the strong petrographic divergence between the extreme links, there appears to be every probability that gneiss and granite with reference to their common origin and age belong to one and the same main group.

Gneiss is on the whole poor in accessory minerals; but in micaceous gneiss, red garnets are often found in great abundance. Also blue disthene is found in one place in the gneiss. Graphite often appears in it in the shape of leaves or lumps. In the grey gneiss we find Fahlbands with a sprinkling of Pyrites.

For a more particular estimate of the thickness of the primitive rock occurring here, the necessary data are wanting. That the thickness is however considerable, appears from what may be observed in the occurrence of this rock in the region of Ribbenesó in the parish of Karlsó.

The so-called primitive rock here treated of is probably that which may be most likened to the Laurentian formation observed in Canada. This formation is here supposed to be divisible into an older and a younger section.

II.—The Tromsó mica-slate group occurs in the coast-tract Island-group in several places over a greater or less area. For instance, in Sóró, Loppen, Vanna, Ringvatsó, Kvaló, Senjenó, Hindó, while in the islands of Lofoten and Vesteraalen it is almost entirely suppressed. But it forms especially a very prominent link of structure in the mainland tract proper of the Tromsó Amt.

The mica-slate group is formed of mica-slate, quartzitic slate, and sometimes also hornblende-slate; but the strata of greyish-white coarse granular limestone are most frequently occurring and characteristic of the group.

Intercalated beds of a greenish actinolite slate are observed in various places. In Tromsö there are layers of an eclogitic rock alternating with the mica-slate; and along the Gullesfjord at Hindö of garnet rock alternating with coarse granular limestone. Alum-slate is frequently found in the mica-slate section.

The direction of the strike in this section agrees approximately with that observed in the gneiss section. The dip may be partly east and partly west. Through a profile line in an easterly direction from the coast to the boundary of the realm, there occur as many as four deviations in the direction of the dip.

As accessory elements there may be remarked:

1) In the proper mica-slate:—red garnets, with which the rock is often abundantly sprinkled; blue disthene, staurolite, pistazite, titanite and magnetite, which last mineral may in some places appear in the slate in such abundance as to form an esential element in place of the mica.
2) In the coarse granular limestone:—mica, quartz, pyrites, graphite, the last mineral often abundantly mixed with the stone in small leaves and stripes; also tremolite, often in fine broad bar-like aggregations; felspar and scapolite.
3) In the green amphibolitic actinolite slate:—yellow epidote.
4) In the amphibolitic partly eclogitic rock:—black hornblende, inlaid like porphyry, magnetite, quartz, titanite, tourmaline, pistazite, garnet, calcareous spar, scapolite, apatite and oligoclase (with twin striation).

In a quartz vein which traverses the mica-slate there has been found reddish fluor-spar. Layers of the Fahlband character are found in some places sprinkled with copper pyrites. The thickness of the group reaches up to 1900 mètres. Petrifactions have not hitherto been observed. The age is consequently undecided. Probably it is old Cambrian (perhaps analogous to the Huronian formation).

III.—The slate-field of Balsfjord occurs in large connected tracts in the interior of the Amt of Tromsö, and further in some of the islands of the coast tract, viz. Ringvatsö and Hindö. The group is formed of a series of layers of argillaceous slate, argillaceous mica-slate, shining slate, and hard slate. Among these there are found thick inlayings of a limestone, which is partly coarse-grained and greyish, partly bluish-black and carboniferous, and often rather fine grained. Alum-slate also occurs frequently between the layers of the slate group.

The limestone often contains much magnesia (magnesian limestone). The latter often contains magnetic iron, which also appears in more connected vein-like masses. In the quartz-layers connected with the group there are found in some places, in drusy cavities, very beautiful rock crystals.

Argentiferous galena occurring in lumps in layers of quartz and limestone is found in one place, namely, the mountain district of Rubben at Bardo.

With the Group II., as also with the Group III., there are connected frequent layers of soap-stone, in which may be found both Bitterspar and pyrites.

The direction of the strike in this group is predominantly 60° to 70°, the dip northerly, usually slight and seldom over 30°. Petrifactions have not been observed in this group. The age is, consequently, undecided—probably younger Cambrian (may possibly be designated as Taconic). The thickness of the group is considerable, but cannot at present be ascertained.

IV.—The Alten and Kvœnangen group (the Raipas system, Tellef Dahll) appears most developed at the bottom of the Altenfjord in West Finmark, always in wider and narrower stripes towards the bottoms of several of the fjords of East Finmark. In the Amt of Tromsó it appears along the interior of Kvœnangen well developed, on the island Vanna, in the parish of Karlsó, and again in several places on the mainland; but here it is generally quite subordinate. The series of strata of the group is formed of black, green, red, and violet argillaceous slate, quartzite and reddish sandstone. The most significant link is, however, a yellowish-white magnesian limestone (Dolomite), which occurs in layers, and in some places may attain a thickness of up to 30 mètres. The slate tracts of the group are often traversed by veins of red hæmatite (Iron mica). There is, moreover, a deposit of copper ore (copper pyrites and variegated copper ore, erubescite) connected with this group, but specially only in the characteristic greenstone formations, which frequently traverse the strata. The mining fields of Kaafjord and Kvœnangen are thus traversed by veins of quartz and lime traversing the greenstone.

The position of the layers in the group is most frequently characterized by strong sinuosities and contortions. The thickness of the series of layers cannot therefore be determined with any great degree of accuracy. Neither have any petrifactions been found in this group. The age is probably Silurian (or Devonian).

V.—The Golda group (the Gaisa system, Tellef Dahll) appears as the final link completing the rock foundation in large connected tracts in East and West Finmark, and can moreover be traced down through the interior of the "Amt" of Tromsó, along the frontier of the realm towards the south to Övre Rostavand. The series of strata is formed of clay and argillaceous mica-slate, mica-slate, quartz-slate, and sandstone quartzite, and moreover of yellow and red sandstone, which completes the series. Inlayings of limestone are, so far as has hitherto been ascertained, entirely wanting. The mica-slate may in some places be richly sprinkled with small red garnets. No other accessory component parts have been observed.

At Bescades —a mountain tract along the Alten river—there appear a few thick layers of tolerably pure graphite (Tellef Dahll). On account of the absence of petrifactions, the age of the group cannot at present be accurately determined. It is perhaps Devonian.

The groups of the Secondary period are here quite unrepresented,—a locally occurring section of the Jura formation at Andó in Vesteraalen only excepted. Neither is there here any representative of the Tertiary formation. On the other hand, there are in several places formations from the Quaternary period along the beds of rivers and channels, consisting of layers of clay and sand, which contain numerous remains of the shells of species of Molluscs which are all now living on our coasts and in our fjords. These formations are observed up to an elevation of about 60 mètres above the present level of the sea. The formations of the Quaternary period are completed by the banks of shells, that is, by a layer of about two mètres thick entirely composed of remains of shells of species of Molluscs now living. These banks of shells, of which the formation is still progressing, are observed up to an elevation of about 10 to 12 mètres above the present sea-level. Moreover, it may be remarked in this respect that on many points along the coast there is found pumice-stone washed up—in some places even in great quantities; which is still at this day continually washed up by the sea-currents, to an elevation of about 26 mètres above the present sea-level.

Throughout the Quaternary period the land has been subjected to an upheaving of about 120 mètres, and this elevation has been continued down to the historic time. As to whether the land is still rising there is no positive evidence existing. In any case, it is certain that the elevation during the last 1000 years has been quite insignificant. When it is stated in so many quarters as a geological fact, that the northern part of Norway rises about one-third of a mètre in a century, this rate is evidently much too great.

With respect to the question whether the elevation noticed during the Quaternary period has taken place by sudden impulses, or evenly and slowly, it is in any case certain that the land as regards the last ten mètres has risen slowly and regularly.

The unstratified rocks which break forth through the tracts of country here noticed are—

1. The gneissoid granite of the coast-tract, which forms relatively the greatest part of the groups of islands of the coast-tract. It appears, sometimes, as a striped granite; sometimes as a granite gneiss and as gneiss granite; but often also as pure granite, through all possible transitional forms from gneiss to pure granite. The felspar is usually formed of reddish orthoclase, but oligoclase occurs also. The mica is most frequently brown magnesian mica.

In some places hornblende takes the place of the mica; and the rock then goes over to hornblende-granite. Red garnets are found in some places in the gneissoid-granite. Magnetite and pyrites are frequent accessory minerals.

The gneissoid granite is often traversed by layers of quartz, which are sometimes thick. In one place the granite is found traversed by veins of carbonate of lime. The gneissoid granite forms most frequently wild mountain tracts, whence there shoot up series of peaks and pinnacles, the shapes of which are often very wonderful. Some of these may reach to a height of about 1300 mètres. Open ways or tunnels traverse many of the mountains that are formed of gneissoid granite. Some of these tunnels are situated at an elevation of about 500 mètres above the sea-level.

2. Inland Granite.—Various larger and smaller granitic masses crop up in the interior as well in the Amt of Finmark, as in that of Tromsó. The Inland granite in the Amt of Tromsó may often be regarded as an oligoclase granite; oligoclase being here often found tolerably predominant by the side of orthoclase.

3. Gabbro or Hypersthenite crops out in thick masses in the northern part of the Amt of Tromsó, as also in West Finmark. The

thickest of these masses forms the Gabbro field of Lyngen, extending from the bottom of Balsfjord in a south and north direction, between Ulfsfjord and Lyngenfjord, to a length of about nine geographical miles, and with an average breadth of about one mile. The islands of Kaagen, Arnó, Seiland, and Sóró are likewise traversed by considerable courses of Gabbro. Moreover, Gabbro-like masses of a more subordinate character break forth in the gneissoid granite of the coast-tract.

The land tracts formed of Gabbro are in the highest degree wild and rugged. In this respect the Gabbro course of Lyngen is particularly remarkable, shooting up in an infinity of peaks and inaccessible pinnacles, of which some attain a height of about 2000 mètres.

The Felspar of the Gabbro is formed of plagioclase (Labradorite and anorthite)—a form which G. Rose termed eucritic—sometimes of Saussurite (Saussurite Gabbro). The augitic element is partly diallage, partly also hypersthene. Sometimes the rock may also go over to a hornblende-gabbro. Olivine is a tolerably frequent mixture. Magnetite, Titanic iron, and Pyrites are frequently found in the rock; sometimes also copper pyrites and apatite.

A smaller mass of Gabbro breaking forth in the west side of the great Senjen island is traversed by a thick vein of magnetic pyrites mixed with copper pyrites. The magnetic pyrites contains here 2 to 3 per cent. of nickel. The important nickel works of Berg are situated on this lode. Masses and courses of serpentine are often connected with the Gabbro. The serpentine is here probably only a transformation product of the Gabbro.

4. Greenstone—sometimes more coarse-grained, sometimes fine-grained—is frequently found connected with the Raipas group in Alten and Kvœnangen, and on the island of Vanna, in the parish of Karlsó. The chief elements of the rock are hornblende and plagioclase. The stone is often traversed by stripes of yellow epidote, sometimes associated with calc-spar and scapolite. Mica, apatite, magnetic iron, pyrites and copper pyrites are not seldom found as accessory minerals.

The greenstone does not form, like the Gabbro and Hypersthenite, deep mountain courses, but appears usually in a more subordinate form, either in small hills, or breaking forth between the layers of the Raipas group, and often covering the same in more or less plate-like masses.

5. Olivine rock—an independent rock—appears in two places in the Amt of Tromsó, namely, on the high plateau immediately to the north of Tromsdalstind, and also at Skutvik lake, on the peninsula between Malangen and Balsfjord. In these two places it forms large isolated hillocks of more than 30 mètres in height. The olivine stone is a beautiful rock of olive-green colour, inlaid with enstatite. It exhibits everywhere a transition to serpentine. Also, greenish talc may be found in the rock as a transformation product.

6. Serpentine appears in various points in the tract here noticed —partly as independent masses in isolated hillocks, and partly in connexion with the Gabbro as a transformation product. Chromate of iron is never observed in the serpentine here.

Of the masses here named there is some probability that the gneissoid granite, with the connected masses of purer granite, is a metamorphosed rock connected with the undoubtedly original sedimentary gneiss of the coast-tract, and thus formed at the same time as the stratified masses of the latter, and in the main under similar circumstances.

On the other hand, the inland granite is presumably of irruptive origin. So considered, it is younger than the mica-slate group, the stratified masses of which it has pierced, but older than the slate-field of the Balsfjord, the stratified masses of which lie over the granite, often with a slight angle of inclination, without any subsequent intrusion being anywhere observable.

The Gabbro and the hypersthenite break through the mica-slate group, and partly also the Balsfjord slate group, and are therefore younger than these, but older than the Raipas group. The greenstone which traverses the Raipas group is younger than it, but older than the Gaisa group. We have, therefore, here to distinguish between the older Gabbro and the younger greenstone (younger Gabbro).

The age of the olivine rock cannot be accurately determined. It is probably older than the Tromsó mica-slate group.

The following synoptical table will assist in elucidating this subject:—

A.—Stratified Groups.

I. Primitive rock (probably Laurentian).
II. Tromsó mica-slate group (probably Huronian).
III. Balsfjord slate-field (younger Cambrian, probably Taconian).
IV. The Alten and Kvœnangen group (Raipas group), Silurian.
V. Golda group (Gaisa system), perhaps Devonian.
VI. Jura formation, a quite locally-appearing section at Andó, with coal layers (Ammonites, Belemnites, Pecten, etc.).
VII. Quaternary formation:—
(*a*) Glacial period.
(*b*) Post-glacial period.
(1) Older section.
(2) Younger section (the Gulf-stream period).

B.—Unstratified.

I. Gneissoid granite (Laurentian).
II. Inland granite (post-Huronian).
III. Gabbro, hypersthenite (post-Taconian).
IV. Greenstone (post-Silurian).
V. Serpentine.
VI. Olivine stone.

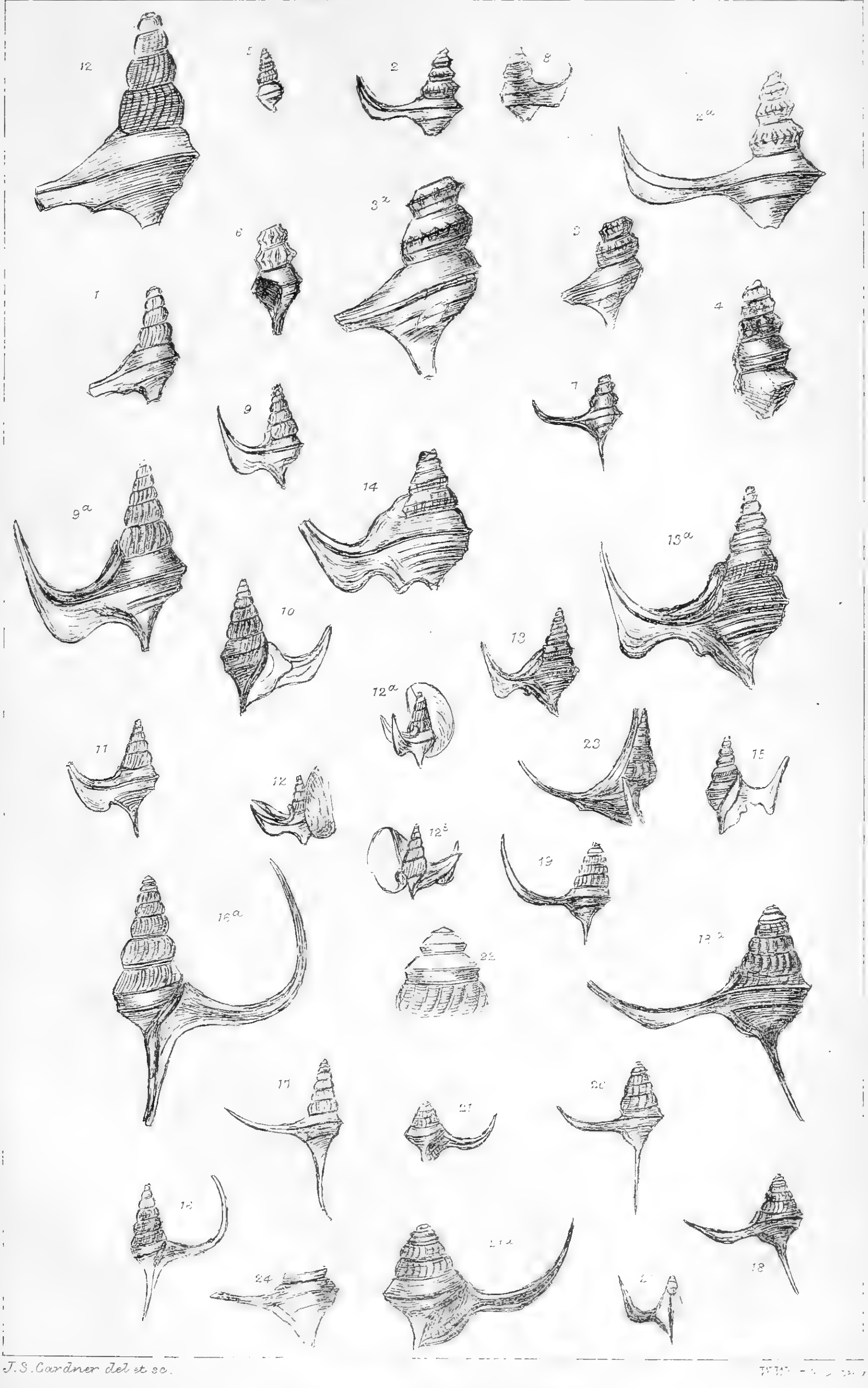
II.—On the Cretaceous *Aporrhaïdæ*.

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

(PLATE XII.)

(*Continued from page* 298.)

When I commenced these notes at the beginning of this year, I expressed a regret that "I cannot include the Aptien and Neocomian species, but the collections at present open to me are too meagre to give anything like a complete account of them. . . . I have also reason to believe that many undescribed species exist from the Upper



J. S. Gardner del. et sc.

Greensand, Chloritic-marl, and Chalk, in cabinets which I have not yet seen, and I should be obliged to any one who would inform me of them."

I have made an endeavour to supply this want of information, and in reply to the hope I expressed, that my attention might be directed to collections I had not seen, I had kindly sent to me specimens by Mr. C. J. Meÿer, Mr. Jukes Brown, and Mr. E. B. Tawney. I have also been able to see the Cunnington collection, which a month or two ago was purchased by the Government, and lodged in the British and Jermyn Street Museums. Instead of confining myself, as I at first intended, to the Gault of Folkestone, I can also now include the Neocomian and the Grey Chalk, from which I have recently collected specimens myself. The result of the additional information I have thus gained is that I am now in the position to offer a different grouping from that which I have already suggested.

My proposed grouping now is given on page 394.

On Dimorphosoma.

When I first described the series of specimens of *Aporrhaïs calcarata,* Sby., I, in common with others, was led to consider them local varieties, which were the result of local conditions of sea. This is a natural inference at first sight; for while there is so great a similarity in the apical whorls, the invariably bicarinated body-whorl, the simple wing, and the more or less ribbed spire, which are common to all the specimens, it is not so apparent that the minor characters are constant.

A suggestion of Mr. Meÿer's has led me to carefully inspect a large number of specimens, many of which he has kindly lent me himself. My information has also been extended by my recently finding three distinct species in the Chalk near Dover. Besides the easily recognizable constant characters mentioned above, the characters which I regarded as varietal I now find to be also constant throughout all the large number I have seen, and I therefore now consider them to have specific value. These characters are given seriatim further on.

Still more important is the suggestion I am about to make that this group ought to be recognized as constituting a separate genus, possibly indeed it may have to be regarded as a separate family. I suggest this on the ground of what I suppose to be their mode of growth.

Mode of Growth.—All specimens of the fry are seen to be keeled and without transverse ribs: with the third or fourth whorl a wing process is developed, and in most cases these whorls become ribbed. This early development of the wing and its persistence throughout the whole growth of the shell is a very unusual character. In the families of *Strombidæ* and *Aporrhaïdæ* the wing is produced only after the shell has attained its adult stage, at which time the growth of the shell is confined to forming and thickening the wing in successive layers, instead of increasing the number of whorls.

FAMILY *APORRHAIDÆ*, Gray, 1856.

GENERAL CHARACTERS OF FAMILY.—*Shell.* Fusiform with dilated wing.——*Spire.* Turreted and tapering.——*Whorls.* Keeled, striated, generally ribbed and tuberculated.——*Aperture.* Narrow, with an anterior canal.——*Outer lip.* Produced, either with expansion or one or more digitations.——*Inner lip.* Polished, and generally thickened.

GENUS.	Whorls.	Shape of Spire.[1]	Angle.	Keel.	Ribs.[2]	Wing.	Attachment of Wing	Canal.	Remarks and Range.
ORNITHOPUS.	5—6	short	$37\frac{1}{2}°$–40°	always 2	none	3 or 4 long, flexuous recurved digits	to apex of spire	long, flexuous, recurved	Intermediate in characters between *Strombi* and *Aporrhaïdæ*—Neocomian to White Chalk.
TRIDACTYLUS	8	pupæform	not measurable	2 or 3	sometimes	2 very long flexuous digits	to body-whorl only	very long, flexuous, and recurved.	Distinct, new, only observed in the Gault here and on the Continent, but *R. pupæformis* of the Oolite belongs to the same group.
APORRHAIS Section I.	8—10	medium	30°	generally none	always rarely tubercular	expanded quadrate, prolonged posteriorly into a sharp point	to last 2 whorls only	moderately long.	Represented by *A. occidentalis*, recent. Mr. Tate proposed for this group the subgeneric name of *Perissoptera*. Neocomian—Chalk.
Ibid. Section II.	10—12	long	20°	1—2	always present, sometimes with nodes, in some cases only rudimentary.	narrow, long, bifurcate	to last whorl	long, straight	=*Alaria* of Morris and Lycett—Gault and Upper Greensand, but represented in the Neocomian on the Continent.
DIMORPHOSOMA.	6—8	medium, apex obtuse	30°	2—3 1 always hidden by suture, except on last whorl	generally present except on apex and last whorl.	long, formed of one digit only	to last 2 whorls.	moderately long.	=*R. calcarata*, Sby. For description see next page—Neocomian, Chalk.

[1] By *long*, I mean a spire whose length is *over twice* that of the width of the penultimate whorl.
" *medium* " " *under twice* " " "
" *short* " " *less than once* " " "

[2] The term *ribs* I use for the markings *transverse* to the whorls. Keels and striæ are parallel to the whorls.

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

Their mode of growth seems to me to have been as follows, which is entirely different from that of any known recent shell. The animal had the power of absorbing the upper or dorsal layers of the wing at the same time that the ventral layers were deposited, in the same manner that the cowry removes the internal layers of its shell wall, and deposits new layers externally with its overlapping mantle. In support of the idea that the wing follows the aperture of the shell, and is continuously absorbed behind by the left edge of the mantle, I have seen in many of the specimens in Mr. Meÿer's collection, that when small, oysters have grown on the back of the shell, so as to interfere with the possibility of the absorption; the old wing has been simply left behind, and an entirely new one developed. The figures which illustrate this are Pl. XII. Figs. 12, 12*a*, 12*b*. The ribs were deposited after the formation of the whorl, by the inner margin of the mantle, and possibly they were formed of the material absorbed from the wing. There is a case recorded by Mr. J. Gwyn Jeffreys which is of interest as throwing a side light on this subject. Speaking of *Pleurotoma,* he writes: "A specimen in my cabinet, from the body-whorl of which a large piece had been taken away at one time, exhibits a peculiar sort of repair; the renewed portion has no trace of longitudinal ribs, although the spiral sculpture is replaced." [1]

If the growth was as I suggest, it follows that the ribs are not homologous with the varical ribs of *Scalaria.* Mr. Reeve and others have long since drawn attention to the solvent properties of the juices of *Cypræa, Conus,* etc.; whilst *Murex* and other varicose Gasteropoda have the power of removing portions of the varices or spines of the last formed whorl, which would obstruct the growth of the overlapping succeeding whorl. Many *Cerithia,* which in their younger stages have dilated lips or recurved canals, surely must possess this power, and this remark also applies to *Persona, Cassis, Typhis, Ricinula,* etc. A different opinion is, however, held by Mr. Gwyn Jeffreys, who, for no reason, as far as I can find, that he has given, objects to this view.[2] In the present case we must suppose the mantle to have been spread as in *Sycotypus* (*Pyrula*) *ficus,* but still conforming to the shape of the shell, which enabled it to absorb from the dorsal side. It seems doubtful whether the form of any of the recent winged families would enable them to produce their shells in this manner.

Genus Dimorphosoma,[3] Gardner.

Shell fusiform, with dilated wing, spire elongated; always possessing two, rarely three keels, which are generally obscured, except on the apex and last whorls, by transverse ribbing; whorls numerous, usually finely striated, sometimes smooth, either keeled or ribbed transversely; apex more or less obtuse; aperture narrow; with a long or short canal in front; outer lip expanded into a simple grooved digitation. The wing attached to the last two whorls only.

Dimorphosoma kinclispira,[4] Gardner. Neocomian. Pl. XII. Figs. 1, 1*a*.

Shell elongated; apex obtuse; whorls 7 or 8, inflated and rounded, ornamented by numerous longitudinal oblique, flexuous ribs, extending to the sutures. The ribs vary in number and prominence, there being about twenty and fourteen respectively on the penultimate whorls of the two known specimens; they are crossed by numerous distinct, irregular raised spiral striæ, which are seen with an inch power to be angulated. The upper side of the last whorl is destitute of ribs, but has a very salient median keel, and a second subordinate keel in front; one of the spiral lines between the keels is more distinct than the rest. The canal appears to have been long; the margin of the outer lip in front of the wing is angulated; the wing is simple, strong and ridge-like, projected slightly downwards.

[1] J. G. Jeffreys, vol. iv. p. 397.
[2] *Ibid.* pp. 306, 403.
[3] Two-shaped body.
[4] κιγκλίς, a lattice.

Found in the Cracker rocks at Atherfield. Described from two specimens in the Jermyn Street Museum.

DIMORPHOSOMA ANCYLOCHILA,[1] Gardner. Neocomian. Pl. XII. Figs. 2, 2*a*.

Shell elongated; whorls 6 or 7, very angulated, their median keel tuberculated, sutural keel plain, intervals smooth, without spiral striæ. The last whorl possesses two angular keels; the posterior considerably predominating, and the anterior being the sutural keel of the spire; the greater keel is continued into the wing. The wing is narrow, simple, thick and angular like a roof-ridge; for some distance it is at right angles to the axis of the spire, and then curves gradually upwards, slightly expanding at the point of curvature.

Found in the Cracker rocks at Atherfield. Described from a single specimen in the Jermyn Street Museum.

DIMORPHOSOMA PLEUROSPIRA,[2] Gardner. Neocomian. Pl. XII. Figs. 3, 3*a*, 4.

Shell elongated; whorls 7 or 8, last two rounded, upper whorls angulated, possessing three keels. On the upper whorls the first keel is strong, salient, and tuberculated, with 9 or 10 tubercles on each whorl; the second keel is indistinct; the third is well marked and sutural; on the penultimate whorl the two keels assume about equal prominence, the upper one being still faintly tuberculated; the last whorl has all three keels well developed, the median one being least prominent. The wing appears to be strong, and projected slightly downward. The shell is unusually destitute of spiral striæ. Under the microscope faint transverse structural lines are visible.

This species is found in the Lower Greensand at Peasemarsh. Mr. C. J. A. Meÿer has several specimens in his collection, the most perfect of which are selected for illustration.

DIMORPHOSOMA VECTIANA, Gardner. Aptien. Pl. XII. Figs. 5, 6, 7.

(*Insula Vectis*, Isle of Wight.)

Shell elongated; whorls 6 or 7, angulated; upper keel replaced by rather produced, elongated tubercles, except on the last whorl; sutural keel smooth and distinct; last whorl with two salient keels, rather close together, the posterior being the more prominent; spiral striæ none, except on the dorsal side of the anterior canal; the wing is simple and curved upward, elongate, and narrow; anterior canal moderately long.

Found at Shanklin, in the Folkestone beds of the Lower Greensand. Mr. Meÿer has kindly shown me about a dozen specimens in his collection, three of which are selected for figuring. Fig. 7 is from a cast only, the shell having broken away; the canal and wing process are, however, well preserved.

DIMORPHOSOMA sp.? Aptien. Pl. XII. Fig. 8.

A cast of an Aptien species with expanded wing is represented at Fig. 8. It is probably distinct from that described above, and is from the same locality.

[1] ἀγκυλίς, a hook. [2] πλευρα, a rib.

DIMORPHOSOMA CALCARATA, Sby. Blackdown beds. Pl. V. Figs. 7, 7*a*, 15, 15*a*; Pl. XII. Figs. 9, 9*a*, 10, 11, 12, 12*a*, 12*b*.

Shell elongated, slightly pupæform; whorls 7 or 8, rounded but slightly flattened; keels totally obscured by ribbing, except on the dorsal side of the last whorl and on the apex; ribs oblique, flexuous, thick and regular, with a tendency to form varices, 17 or 18 on the penultimate whorl; apex minute, obtuse with rounded, smooth whorls, carinated at their base. Body-whorl distinctly striated, with a strong rounded posterior keel and subordinate anterior keel, one of the striæ below the anterior keel being more prominent than the rest; no ribs on the dorsal, but ribbed on the ventral side. The principal keel is continued on to the wing in the form of a ridge ending in a sharp point. The wing is simple and more expanded than in the other associated Blackdown species, projected at first at right angles to the axis of the spire, and then curving rather abruptly upward, terminates in a point three-fourths of the height of the spire; margin entire, region above the rib narrow and thickened. Outer lip expanded into the wing, thickened internally into a second triangular spoon-shaped lip, smooth; inner lip thick; aperture narrow; canal short.

This species is that originally described by Sowerby. Its history is given at page 129 of this MAGAZINE. It is found at Blackdown. Mr. Meyer, who has kindly given me the opportunity of examining the many hundreds of specimens in his collection, informs me that this shell is about five times more numerous than that next described, with which it is found associated. It is just possible that this may be the male, and *D. neglecta* the female, as in *Fusus*, an allied family. Mr. Gwyn Jeffreys remarks: "Of many hundreds of specimens which I have examined, the males were more numerous than the females."[1]

DIMORPHOSOMA NEGLECTA, Tate. Blackdown. Pl. V. Figs. 8, 8*a*, 9, 16; Pl. XII. Figs. 13, 13*a*, 14, 15.

Shell resembling in form that of the species last described; whorls 7 or 8, ventricose, slightly angulate, keels visible on all except those near the apex; region above the keel nearly smooth or with spiral lines; that below marked by fine straight oblique ribs, which do not quite reach to the suture, but impress the median keel; they are crossed by 3 or 4 strong striæ, and there are 2 or 3 more striæ nearer the suture. The number of these spiral striæ and the prominence of the ribbing are most variable, the ribs being sometimes scarcely present, but generally most strongly developed on the penultimate whorl; they may usually be seen on the dorsal side of the last whorl in the form of small oblique tuberculations crossing the keel. The wing is at first constricted, notched, with a single tooth in the notch, and then expanded and curved upward—never having the triangulate inner thickening; in one specimen figured, Pl. V. Fig. 16, it is bifurcate.

[1] J. G. Jeffreys, vol. iv. p. 337.

It is found at Blackdown, where it is less common than *D. calcarata.* An examination of a very large series of specimens fails to show any decided intermediate form between the two species. Mr. R. Tate, in the Geol. and Nat. Hist. Repertory, Sept. 1865, separated it as a variety of *Aporrhaïs calcarata,* under the name of *A. neglecta.*

DIMORPHOSOMA TOXOCHILA,[1] Gardner. Gault. Pl. V. Figs. 10, 12.

Shell elongated; whorls 7 or 8, rounded, inflated; keels obliterated, except on apical and body-whorls, other whorls ribbed; ribs pronounced, more or less oblique and flexuous, about a dozen on each revolution; sutures keeled; apex rather obtuse, composed of three smooth angulated whorls, with a strong keel rather anterior to their centre. The last whorl is striated, and has two keels, the posterior being the more prominent; on the ventral side the region above the posterior keel is ribbed. The inner lip is incrusted round the aperture, the margin of the incrustation being sharply defined; the outer lip is prolonged into a very long, curved, narrow, and simple wing, grooved ventrally, carinated above. The wing is straight for a quarter of an inch, and is then curved rather suddenly upward, exceeding the spire in length. Anterior canal long and nearly straight; aperture narrow. This shell is more elongated than the Lower Gault species. It is found in the beds immediately above and below the mottled bed in the Folkestone Gault, where it is rare. The beds are numbered 5 and 7 by Mr. F. G. H. Price. It is more elongate and slender than the Lower Gault species.

DIMORPHOSOMA DORATOCHILA,[2] Gardner. Gault.

Shell moderately elongated; whorls 6, sometimes 7, convex, finely and distinctly striated; keels obliterated except on apical and body-whorls; the third whorl is both keeled and ribbed, the other whorls are ornamented by numerous oblique and flexuous ribs; sutures raised, sometimes hidden; apex formed of three broad and very obtuse angulated whorls, which are smooth, with a strong median keel. The body-whorl has two keels, the posterior being the more prominent; the posterior region is slightly ribbed ventrally; the whorl is strongly striated, especially that part anterior to the keels. The wing is long, narrow, simple, forming an acute ridge above; it is curved gradually upward, and terminates in a sharp point. The aperture is narrow, and is incrusted immediately round the columellar lip; the outer lip is toothed; the wing is applied to the last whorl only; the anterior canal is long and straight.

The history of this species is given at page 129, it is confined to about a single foot of the Gault of Folkestone (bed 2 in Mr. Price's paper), and has not been met with elsewhere.

DIMORPHOSOMA OPEATOCHILA,[3] Gardner. Grey Chalk. Pl. VII. Fig. 9.

Shell very elongated; whorls rounded, probably nine; striated; keels entirely obliterated, except on the body-whorl; ribs ten or eleven on each whorl, reaching to the sutures. Last whorl having

[1] τόξον, a bow. [2] δόρυ, a spear. [3] ὀπεάς, an awl.

two keels of nearly equal prominence, striated between. Wing simple, long, narrow, awl-shaped; aperture narrow; anterior canal short, outer lip sinuous.

This shell differs from the figures of *R. calcarata, composita,* and *stenoptera* of German authors in the length of the wing and want of ribs crossing the keels on the last whorls. It was found in the cast bed of the Grey Chalk, at Lyddenspout, between Folkestone and Dover, and is described from a single specimen.

DIMORPHOSOMA SPATHOCHILA,[1] Gardner. Grey Chalk, Pl. VII. Fig. 10.

Shell elongated, turreted, whorls with few very prominent oblique ribs, body-whorl with two keels; wing simple, at first constricted, then widening into a bladebone-shaped expansion; the channel in the wing is nearly straight, and forms an angle of 70° with the axis of the spire; the wing was probably twice the length of the specimen figured, and was pointed as usual in this group. Aperture narrow, anterior canal short, and connected with the wing by an expanded outer lip, with sinuous margin. The form of the canal and the connecting lip is similar to that in *D. opeatochila,* and is an unusual one in the group.

Found with the species last described, and described from a single specimen.

EXPLANATION OF PLATE XII.

FIG. 1.—*Dimorphosoma kinclispira,* Gardner. Natural size. Neocomian, Atherfield. From the Jermyn Street Museum.
FIG. 1*a*.—*D. kinclispira.* Enlarged twice.
FIG. 2.—*D. ancylochila*, Gardner. From the Jermyn Street Museum, Atherfield.
FIG. 2*a*.—*D. ancylochila.* Enlarged twice.
FIG. 3.—*D. pleurospira*, Gardner. Neocomian, Peasemarsh. Mr. Meÿer.
FIG. 3*a*.—*D. pleurospira.* Enlarged twice.
FIG. 4.—Another specimen.
FIG. 5.—*D. vectiana*, Gardner. Aptien. Shanklin, Isle of Wight.
FIG. 6.—A shell enlarged twice. Shanklin, Isle of Wight.
FIG. 7.—A cast of the same, showing length of wing and canal.
FIG. 8.—*Dimorphosoma* sp.? With expanded wing. From the same locality.
FIG. 9.—*D. calcarata*, Sby. Blackdown beds. From Mr. Meÿer's collection.
FIG. 9*a*.—*D. calcarata.* Enlarged twice.
FIG. 10.—*D. calcarata.* Showing aperture with internal thickening.
FIG. 11.—*D. calcarata.* To show length of canal, which is usually broken off.
FIG. 12, 12*a*, 12*b*.—*D. calcarata.* To show wing with interrupted growth.
FIG. 13.—*D. neglecta*, Tate. Blackdown bed. Mr. Meÿer.
FIG. 13*a*.—*D. neglecta.* Enlarged twice.
FIG. 14.—*D. neglecta.* An old specimen.
FIG. 15.—*D. neglecta.* Showing aperture.
FIG. 16.—*D. toxochila*, Gardner. Gault, Folkestone. Author's cabinet.
FIG. 16*a*.—*D. toxochila.* Enlarged twice. Author's cabinet.
FIG. 17.—*D. toxochila.* Another specimen. Author's cabinet.
FIG. 18.—*D. doratochila*, Gardner. Gault, Folkestone.
FIG. 18*a*.—*D. doratochila.* Enlarged twice.
FIG. 19, 20.—Other specimens of same species. Nat. size.
FIG. 21.—*D. doratochila.* Shows denticulated aperture.
FIG. 21*a*.—Same enlarged.
FIG. 22.—*D. doratochila.* Apex very much enlarged.
FIG. 23.—*D. opeatochila*, Gardner. See also Plate V.
FIG. 24.—*Aporrhaïs* ? sp. nov. Grey Chalk, Dover.

[1] σπάθη, a blade.

THE METEORITE WHICH FELL AT BUSTI, BETWEEN GORUCKPUR AND FYZABAD, INDIA, 2ND DECEMBER, 1852
(Actual Size.)

M & N. HANHART LITH.

III.—A Chapter in the History of Meteorites.

By Walter Flight, D.Sc., F.G.S.,
Of the Department of Mineralogy, British Museum.

(*Continued from page* 372.)

(PLATE XI.)

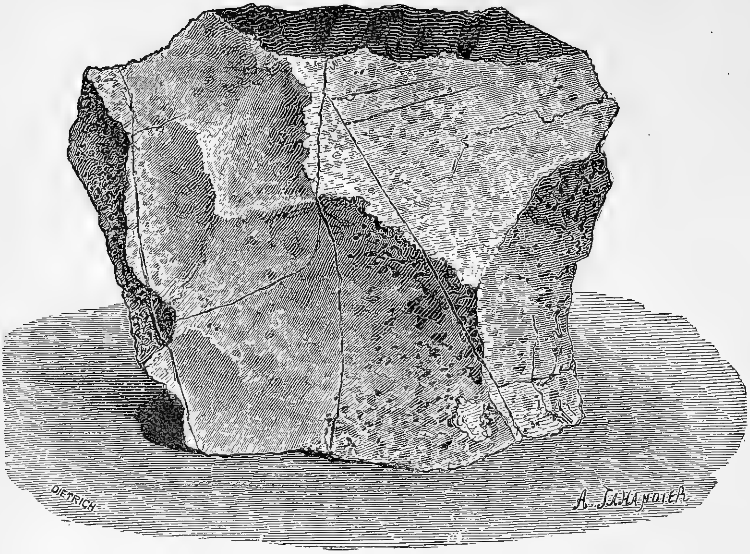
Found 1840.—Hemalga, Desert of Tarapaca, Chili.[1]

Greg,[2] and likewise Heddle, found cavities in certain portions of this iron, some of the size of a pea, which are filled with metallic lead; this is the only instance where that element has been met with in a meteorite. Dr. Lawrence Smith has recently examined several specimens cut from the original mass, and is of opinion that the lead is altogether foreign to the iron, being doubtless derived from material with which the block was probably treated by the original discoverers for the purpose of extracting some noble metal from it. The lead, he finds, occurs only in cavities near the surface of the mass, which have channels of more or less size leading to the surface. In pieces of the iron detached from the interior of the block and free from fissures no lead could be discovered.

1842, June 4th.—Aumières, Dép. de la Lozère, France.[3]

In an interesting series of papers on the study of rocks, especially as regards the analogies in point of structure and mineral composition which are to be traced between the terrestrial rocks and those met with in meteorites, Meunier has adopted the following classification for the latter series: 1. Normal; 2. Brecciated; 3. Metamorphic; 4. Eruptive; 5. Rocks traversed with veins (*filonniennes concrétionnées*); and 6. Volcanic.[4] The iron of Deesa (which see) he regards as an example of an eruptive meteorite, the stone of Chantonnay represents the class with veins entirely rocky. The veins of cosmical rocks show as many varieties as terrestrial rocks. The upheaval of rocks on our globe presupposes the existence of faults, that is to say, of vents which establish a communication between the earth's interior and the atmosphere. Faults are recognized by the throws which the rocks constituting their two sides have undergone; these rocks, although preserving their continuity, are shifted vertically in masses that may be very considerable. The more the surface of these faults shows traces of violent friction, the more they become polished, channelled, or striated. In the same way meteorites in a number of cases exhibit true faults, with throws and polished surfaces. In the meteorite of Aumières, of which a representation is given on the next page, one fault is seen to cut another again to which it gives a downthrow of several centimètres.[5]

[1] J. L. Smith. *Amer. Jour. Sc.*, 1870, xlix. 331.
[2] R. P. Greg. *Phil. Mag.* [4], x. 12.—*Amer. Jour. Sc.*, xxiii. 118.
[3] S. Meunier. Les Pierres qui tombent du Ciel. *La Nature*, 1873, i. 403.
[4] This classification is, it is to be presumed, merely tentative.
[5] The second fault is described in Meunier's paper as being above on the left-hand side of the figure in a position nearly horizontal, and continued below on the right parallel to the first direction, being thrown down more than five cm. by the great



The stone of Aumières consists of a grey rock, like that forming the meteorite of Aumale (1865, August 25th), which possesses the remarkable property of turning black when heated. By the friction of such surfaces and the consequent development of heat the adjacent surfaces undergo a true metamorphism, and the grey face as a consequence becomes black. The faults in such cases have the form of black lines which have very much the appearance that they would present if traced with a pen. On comparing different fragments it becomes evident that where the throw and as a consequence the mechanical effect have been considerable, the black lines have a more marked character. The thickness indicates the degree of dynamic energy to which the stone has been subjected, and the grey rock of Aumale and Aumières is in fact an extremely sensitive thermometer of a kind that may render great service in the study of the conditions to which meteorites may have been exposed.

1843, June 29th.—Manegaum, near Eidulabad, Khandeish, India.[1]

The conspicuous ingredient in this stone is a pale yellow-green, or primrose-coloured mineral, with a tint similar to that of a very pale

oblique fault. It seems, however, that his description is taken from the block and not the engraving, which by his kind permission I have reproduced; and that the two faults respectively referred to are: one of those on the top towards the right, the other that which appears to connect the two great perpendicular veins.

[1] N. Story-Maskelyne. *Philosophical Transactions*, 1870, clx. 189.—*Proc. Royal Soc.*, xviii. 146. For an earlier notice see *Phil. Mag.*, 1863, xxv. 39, and *Journ. Asiat. Soc. Bengal*, xiii. 880. (The date formerly assigned to the fall of this meteorite, viz. the 16th July, has been shown by General Cunningham to be erroneous.) See also C. Rammelsberg. Die Chemische Natur der Meteoriten. *Abhandlungen Ak. Wiss. Berlin*, 1870, 120.

peridot or chrysolite, occurring in crystalline grains, and cemented together with a white opaque silicate. Under the microscope the green granules are seen to be tolerably symmetrical crystals, varying in size from a small pin's head to microscopic dust; they were found on analysis to be a highly ferriferous enstatite or bronzite. They crystallize in the prismatic system, and give the following results of measurements, which accord closely with the numbers obtained by Von Lang when examining the enstatite of the Breitenbach siderolite:

				Breitenbach enstatite.
100, 110	=	About 46°	......	45° 52′
100, 101	=	49° 4′	......	48° 49′
110, $\bar{1}$10	=	About 88°	......	88° 16′
110, 101	=	58° 39	......	58° 24′

The specific gravity of the mineral is 3·198, the hardness 5–6, and the chemical composition:

				Oxygen.	
Silicic acid	55·699	......			29·706
Magnesia	22·799	......	9·119	}	14·059
Iron protoxide......	20·541	......	4·564	}	
Lime	1·316	......	0·376	}	
	100·355				

These numbers agree very closely with those required by the formula ($\frac{2}{3}$ Mg $\frac{1}{3}$ Fe) SiO_3, and show the mineral to be richer in iron than the bronzite of the Breitenbach siderolite. A portion of the meteorite was analysed in its entirety with the following results:

				Oxygen.	
Silicic acid	53·629	......			28·602
Magnesia	23·320	......	9·328	}	14·305
Iron protoxide......	20·476	......	4·550	}	
Lime	1·495	......	0·427	}	
Chromite	1·029				
	99·949				

These per-centages differ to so small an extent from those yielded by the analysis of the picked crystals, that we arrive at the conclusion that both ingredients have the same composition, and find in the Manegaum stone an instance of a meteoric rock consisting of a single silicate. The Ibbenbühren meteorite (1870, June 17th) has since been shown by Vom Rath (see page 71) to be similarly constituted. A very minute amount of meteoric iron, far too small for isolation and analysis, occurs in the Manegaum stone.

Found 1846.—Tula, Netschaevo, Russia.[1]

This remarkable mass of iron, which encloses a number of angular fragments of rocky material and resembles a true breccia, was stated by Auerbach to contain but little nickel. Rammelsberg now finds as the result of two analyses, conducted according to different methods, that the per-centage of this metal (and cobalt) is 10·24 and 9·84, or about four times the amount detected by the earlier observer.

[1] C. Rammelsberg. *Monatsber. Ak. Wiss. Berlin,* 1870, lxx. 444.

1847, February 25th.—Hartford, Linn Co., Iowa.[1]

This meteorite was originally examined by Shepard (*Report on American Meteorites*, 1848, page 37), who states that it consists of 83 per cent. of a silicate to which he gives the name of 'howardite' (an iron-magnesium silicate with the oxygen ratio of $RO : SiO_2 = 1 : 3 \cdot 3$), about 10 per cent. of nickel-iron and 5 per cent. of magnetic pyrites. Shepard moreover asserts in his paper that this extremely acid silicate fuses easily before the blowpipe, and gelatinises with warm dilute acid. Not a little astonished that a silicate of this form should possess such properties, Rammelsberg undertook an examination of this meteorite, which he finds to possess the following composition:

Nickel-iron	10·54
Troilite	6·37
Soluble silicate	41·85
Insoluble silicate ...	41·24
	100·00

The nickel-iron alloy consists of

Iron = 89·75; nickel = 10·25; Total = 100·00.

and the composition of the two portions of silicate separated by the action of acid and sodium carbonate was as follows:

	SiO_2	Al_2O_3	FeO	MgO	CaO	Na_2O	K_2O	
A. *Soluble* ...	38·80	—	21·31	39·89	—	—	— =	100·00
B. *Insoluble* ..	55·08	4·86	13·58	22·70	2·85	0·93	trace =	100·00

The oxygen per-centages of A clearly indicate the presence of an olivine in which the ratio of Mg : Fe is 3 : 1, or the same as that of the variety of this silicate which occurs in the Hainholz siderolite. The insoluble portion, about equal in amount to the above, appears to consist of a bronzite (or bronzite mixed with a little augite), in which Mg : Fe : Ca is as 12 : 4 : 1; the ratio of iron to magnesium in the two minerals forming the chief ingredients of this meteorite is therefore the same. Rammelsberg's results differ altogether from those given by Shepard, and indicate the presence in this stone of those minerals only which are frequently met with in meteorites. 'Howardite' has not been identified as a mineral species in any rock, terrestrial or meteoric.

1847, July 14th.—Braunau (Hauptmannsdorf and Ziegelshlag), Bohemia.[2]

In a memoir on the crystalline characters of iron, and especially of meteoric iron, Tschermak describes the structure of the specimens of Braunau iron preserved in the Vienna Collection. One piece exhibits the cleavage planes of the cube, as well as other smaller faces on the edges and corners of the cube; the angles which these faces form with those of the cube are 70° and 48°, corresponding evidently with those enclosed between the faces of the triakis-

[1] C. Rammelsberg. *Monatsber. Ak. Wiss. Berlin*, 1870, lxx. 457.
[2] G. Tschermak. *Sitzber. Ak. Wiss. Wien*, 1874, Nov.-Heft, lxx.

octahedron (221) and the cubic faces, viz. 70° 31′ and 48° 11′. Faces were noticed in the following positions:

$$221,\ 212,\ 122,\ 2\bar{2}1,\ 2\bar{1}2,\ 22\bar{1}$$

the other six directions, although present, could not be traced on the specimen which the author examined. Occasionally solid angles or corners are protruded from the cleavage planes with faces at right angles to each other and corresponding, as regards their position to the cube, with the directions (221). Little step-like markings, such as are seen on artificial iron, and fine lines, evidently sections of thin plates, are likewise observed in positions that correspond with one or other face of the triakis-octahedron (221). Tschermak shows that the development of these faces is due to twinning, not by contact, but by interpenetration, the normal on 111 being the axis of twinning. Such twinning is met with on crystals of fluor-spar.

By etching the Braunau iron two varieties of figures are developed: with a moderate use of the corroding reagent an orientated sheen is developed, the fine texture exhibiting what von Haidinger termed crystalline damaskining (see page 75). As the author showed in the case of the Ilimaë iron this appearance is due to slight depressions of the surface; they are, in fact, little cubical hollows, the sides of which are parallel to the cleavage faces. A second curious feature brought to notice by etching are little furrows which make their appearance on those parts of the cleavage-face where the fine lines were previously seen, lines which owe their origin to the plates parallel to (221). The twin-lamellæ therefore are more readily acted upon than the mass of the metal.

On dissolving this iron in dilute nitric acid a residue remains which consists of fine yellow metallic needles and excessively thin yellow plates; occasionally particles are met with exhibiting every stage of transition from one to the other of these forms. The plates are not unfrequently broken through, or imperfectly developed, in the manner with which we are familiar in crystals of some varieties of specular iron from volcanic localities. The needles, as Rose has already shown, lie parallel to the edges of the cleavage-cube. Tschermak believes both plates and needles to have the same composition, to be in fact schreibersite. He was not able to determine the crystalline form of this meteoric mineral with the material provided by this meteorite, but he is of opinion that it will be found to be either tetragonal or rhombic.

1850, November 30th.—Shalka, Bancoorah, Bengal.[1]

The mineral characters of this meteorite were first described by von Haidinger and G. Rose, and the chemical investigation undertaken by C. von Hauer, who found the silicates, when analysed in the mass, to give numbers the oxygen ratios of which were: RO to SiO_2 as 1 : 2·435. While von Haidinger regarded the chief constituent of the meteorite to be a silicate to which he gave the name of

[1] C. Rammelsberg. *Monatsber. Ak. Wiss. Berlin*, 1870, lxx. 314.—N. Story-Maskelyne. *Philosophical Transactions*, 1871, clxi. 359.

'piddingtonite,' G. Rose considered it to be composed of olivine and another mineral 'shepardite,' which has now been found to be as hypothetical a species as 'piddingtonite.' Rammelsberg during a recent examination of the meteorite determined it to consist of:

Bronzite	86·15
Olivine	10·92
Chromite	2·39
	99·46

the separation with acid and sodium carbonate yielding the following numbers:

	SiO_2	FeO	MgO	CaO	Na_2O	Chromite.		
A. *Soluble* ...	35·17	35·80	29·03	—	—	—	=	100·00
B. *Insoluble* ...	55·55	16·53	27·73	0·09	0·92	0·33	=	101·15

Rammelsberg therefore finds this meteorite to have a much more simple composition than the earlier investigations, and to consist mainly of a bronzite and a few per cent. of olivine, in each of which the Fe is to Mg as 1 : 3.

According to the results given in Maskelyne's paper, the constitution of this meteorite, or of the portion of it examined in the British Museum Laboratory, appears to be yet more simple. A small amount of the débris of the stone was found to possess the following composition:

		Oxygen.
Silicic acid...	45·370	24·197
Iron protoxide	19·060	4·236
Magnesia	15·636	6·254
Lime	2·214	0·632
Chromite	17·717	—
	99·997	

A mottled grey-coloured mineral, forming the chief constituent of the meteorite, was twice submitted to analysis with the following results:

	I.	*Oxygen.*	II.	*Oxygen.*
Silicic acid	52·831	28·176	52·725	28·120
Iron protoxide...	21·863	4·859	22·992	5·109
Magnesia.........	24·266	9·706	24·085	9·630
Lime	0·502	0·143	—	—
Chromite	0·643	—	—	—
	100·105		99·802	

These numbers correspond with the formula ($\frac{2}{3}$ Mg $\frac{1}{3}$ Fe) SiO_3, which is identical with the bronzite of the Manegaum meteorite (which see).

These results, it will be seen, do not indicate the presence of an olivine. To check them, two weighed portions of the mineral were subjected to the action of hydrochloric acid and sulphuric acid respectively, with subsequent treatment with sodium carbonate in each case, whereby the following constituents were removed:

	I.	*Oxygen.*	II.	*Oxygen.*
Silicic acid	1·507	0·804	3·900	2·080
Iron protoxide...	0·974	0·216	1·799	0·399
Magnesia.........	1·058	0·423	1·877	0·750
	3·539		7·576	

The slight excess of iron oxide found in each case is doubtless due to the presence of a little unseparated nickel-iron. These results confirm the above analysis and fail to indicate the presence of olivine in this meteorite.

Found 1850.—Ruff's Mountain, Lexington Co., S. Carolina.[1]

In an examination of this large block of meteoric iron Shepard detected the presence of only 3·12 per cent. of nickel. By employing two more refined methods of analysis, Rammelsberg now finds:

	I.	II.	*Mean.*
Nickel	7·60	9·65	8·62

which is still within the limit that I find to obtain in those instances where an iron exhibits Widmannstättian figures. (Compare with the list on page 80.)

1852, September 4th.—Mezö-Madaraz, Transylvania.[2]

Allusion has already been made to Rammelsberg's recent investigation of this meteorite (see page 25). His previous researches on the constitution of the meteorites of Kleinwenden, Pultusk, Richmond, and Linn Co., Iowa,[3] had proved them to consist of a mixture of olivine and bronzite, and in his review of the additions made during the last few years to our knowledge of these cosmical masses,[4] he had demonstrated that of the fifty chondritic meteorites which had up to that time been submitted to analysis, the greater part yielded a like result. Certain among the meteorites, however, did not appear to come under this rule; among them is the one mentioned above which had been analysed by Atkinson,[5] who found no iron protoxide in the insoluble portion, and determined the part broken up by the acid to be a trisilicate. The author was led to analyse this stone afresh, and he has arrived at the following results:

Nickel-iron	9·79
Troilite	6·24
Chromite	0·80
Soluble silicate	42·83
Insoluble silicate	40·34
	100·00

The nickel-iron, which has the composition indicated by the formula Fe_5Ni, yielded the following numbers:

Iron = 83·25; Nickel (cobalt) = 16·75. Total 100·00

and the silicates those given below:

	SiO_2	Al_2O_3	FeO	MnO	NiO	MgO	CaO	Na_2O	
A. *Soluble*	36·61	2·19	22·82	0·42	0·14	35·49	0·60	1·02	= 99·29
B. *Insoluble*	52·02	6·08	13·27	—	—	21·85	3·74	3·28	= 100·24
C. *Total*	44·24	4·10	18·25	0·22	0·07	28·98	2·02	2·12	= 100·00

[1] C. Rammelsberg. *Monatsber. Ak. Wiss. Berlin*, 1870, lxx. 444.
[2] C. Rammelsberg. *Zeitschrift Deutsch. Geol. Gesell. Berlin*, 1871, xxiii. 734.
[3] C. Rammelsberg. *Monatsber. Ak. Wiss. Berlin*, 1870, lxx. 440.
[4] C. Rammelsberg. Die Chemische Natur der Meteoriten. *Abhandl. Ak. Wiss. Berlin*, 1870, 75.
[5] E. Atkinson. *Jour. Prakt. Chem.*, 1856, 357; *Phil. Mag.*, xi. 141.

The soluble part is an olivine of the same composition, 3 Mg_2 SiO + Fe_2 SiO_4, as that met with in the meteorites of Hainholz, Borkut, St. Mesmin, Muddoor, Shergotty, etc.; the insoluble portion appears to be a bronzite, in which the bases Ca : Fe : Mg=1 : 3 : 9, accord with those of the variety of this mineral which occurs in the Chantonnay stone. The Mezö-Madaraz meteorite therefore belongs to the large class of chondritic masses above mentioned.

1852, December 2nd.—Busti, between Goruckpùr and Fyzabad, India. [Lat. 26° 45′ N.; Long. 82° 42′ E.][1]

With a view to obtain some more satisfactory means of dealing with the aggregates of mixed and minute minerals, which constitute meteoric rock, the author sought the aid of the microscope, having in the first place sections of small fragments cut from the meteorites so as to be transparent. By studying and comparing such sections one learns that a meteorite has passed through changes, and that it has had a history of which some of the facts are written in legible characters on the meteorite itself; and one finds that it is not difficult roughly to classify meteorites according to the varieties of their structure. One also recognizes constantly recurring minerals; but the method affords no means of determining what these are. Even the employment of polarized light, so invaluable where a crystal of which the crystallographic orientation is at all known is examined with it, fails, except in rare cases, to indicate with certainty even the system to which such minute crystals belong. It was found that the only satisfactory way of dealing with the problem was by employing the microscope, chiefly as a means of selecting and assorting out of the bruised débris of a part of a meteorite the various minerals that compose it, and then investigating each separately by means of the goniometer and by analysis—finally recurring to the microscopic sections to identify and recognize the minerals so investigated. In the memoir mentioned below the author publishes the results of the former part of this inquiry. It is obvious that the amount of each mineral which can be so obtained is necessarily small, as only very small amounts of the meteorite could be spared for the purpose. On this account one has to operate with the greatest caution in performing the analysis of such minerals, and the desirableness of determining the silica with more precision than usually is the case in operations on such minute quantities of a silicate suggested a process which, after several experiments had been conducted with a view to perfecting it, assumed a definite form. The method, which essentially consists in the separation of the silicic acid from the bases by distillation with hydrofluoric acid, whereby the operator is enabled to proceed to the estimation of the whole of the constituents of any silicate in one and the same portion, will be described in detail later on with other new methods of analysis.

[1] N. Story-Maskelyne. *Proc. Royal Society*, xviii. 146. *Philosophical Transactions*, clx. 189. (See also Abstract in *Nature*, i. 382.)—A preliminary notice of this meteorite appeared in the *Brit. Assoc. Report*, 1862, "Notices and Abstracts." Appendix ii. 190.

The first meteorite investigated on the principles here laid down was the remarkable stone which fell at Busti, in India, at the above date. The fall, which took place from a cloudless sky at 10·10 a.m., was attended with an explosion, louder than a clap of thunder and lasting three to four minutes, and must have occurred about the time the stone passed the longitude of Goruckpùr. The meteorite, which weighs about 3 lbs., consists for the most part of the mineral enstatite; at one end, however, are embedded a number of chestnut-brown spherules, in which again were detected minute octahedra having the lustre and colour of gold. These two minerals seem scarcely to have been affected by the heat that fused the silicates surrounding and encrusting them.

The brown spherules are calcium (magnesium) monosulphide, and have been named by the author 'Oldhamite'; their outer surface is generally coated with calcium sulphate. This mineral cleaves with equal facility in three directions which give normal angles averaging 89° 57′, and are no doubt 90°. Its system, therefore, is cubic; in polarized light it is seen to be devoid of double refraction. The specific gravity is 2·58 and the hardness 3·5—4·0. With boiling water it yields calcium polysulphides, and in acid it readily dissolves with solution of hydrogen sulphide. The composition of these spherules was found to be:

		I.	II.
Oldhamite	Calcium monosulphide	89·369	90·244
	Magnesium monosulphide	3·246	3·264
Gypsum		3·951	4·189
Calcium carbonate...		3·434	—
Troilite		—	2·303
		100·000	100·000

The presence of such a sulphide in a meteorite shows that the conditions under which the ingredients of the rock took their present form are unlike those met with in our globe; water and oxygen must have alike been absent. The existence of iron in a state of minute division, as often found in meteorites, leads to a similar conclusion. But if the conditions necessary for the formation of pure calcium sulphide be borne in mind, the evidence imported into this inquiry by the Busti aerolite seems further to point to the presence of a reducing agent during the formation of its constituent minerals; whilst the crystalline structure of the oldhamite and of the mineral next described must certainly have been the result of fusion at an enormously high temperature. The detection of hydrogen in meteoric iron by Graham, and more recently by other observers, tends to confirm the probability of the presence of such a reducing agent.

"Osbornite" is the name given by the author to golden-yellow microscopic octahedra embedded in the oldhamite. These minute crystals gave the following angles:

			Regular octahedron.
$111, 11\bar{1}$	=	70° 27′ and 70° 37′	70° 31′
$111, 1\bar{1}\bar{1}$	=	109° 31′	109° 28′
$111, 1\bar{1}1$	=	69° 58′	

This mineral withstands the action of strong acids, is unchanged when fused with potassium carbonate, and possibly when heated with the chlorate; heated in dry chlorine it glowed for a few seconds, lost its metallic lustre, and left a residue which soon began to deliquesce. The amount, about 0·002 gramme, was too small for anything but a qualitative examination, which showed it to consist of calcium, sulphur, and an element which gives the reactions of titanium[1] or zirconium, probably the former, in some singularly stable state of combination. By heating zirconium to an intense heat with lime and aluminium, Mallet[2] obtained a golden-yellow incrustation, cubic in form, unattacked by the strongest acids, and possibly analogous in its nature to osbornite.

The next mineral described is an augite of a pale violet-grey colour, intimately mixed with another silicate presently to be described; it belongs to the oblique system, the measurements yielding the following approximate values:

			Diopside.
001, 100	=	About 75° 30′	73° 59′
001, 110	=	,, 81°	79° 29′
110, 100	=	45° 54′ to 47° 26′	46° 27′
110, $\bar{1}10$	=	5° 8′ to 86° 20′	87° 5′
100, 111 ?	=	53° 25′ to 54° 15′	53° 50′
001, $\bar{1}10$	=	100° 81′	100° 57′

The plane containing the optic axes is perpendicular to the edge [100,001], and the optical character in the centre of the field is negative. When looked through in any direction parallel to the zone circle [001,010], the crystals show a remarkable dichroism; the plane 100 presents a somewhat facile cleavage, and is also conspicuous for a remarkable metallic lustre, recalling that seen on some kinds of diallage, but of a fine golden hue. The author is of opinion that osbornite may permeate the augite in minute interlaminated layers of sufficient thinness to be transparent.

Two analyses of this mineral gave the following numbers:

	I.	II.	($\frac{5}{8}$ Mg $\frac{3}{8}$ Ca) SiO_3
Silicic acid	55·389	55·594	56·604
Magnesia	23·621	23·036	23·585
Lime	20·020	19·942	19·811
Iron oxide	0·780	0·309	—
Soda	0·554	[0·554]	—
Lithia	trace	[trace]	—
	100·364	99·435	100·000

The iron oxide contains some of the titanoid metal met with in osbornite. In terrestrial varieties of augite the calcium is usually in excess of the magnesium. The mineral was somewhat soluble in acid, the action, however, was found to be simply that of a solvent.

While the augite is present in greatest quantity in the area containing the calcium sulphide, it is met with in other parts of the stone; and associated with it everywhere, and forming the mass of

[1] See researches on the presence of titanium vapour in the solar prominences and chromosphere, by C. A. Young. *Amer. Jour. Sc.*, 1871, ii. 335.

[2] J. W. Mallet. *Amer. Jour. Sc.*, 1856, xxviii. 346.

the stone, is another silicate, which proved to be an enstatite like that of the meteorite of Bishopville (1843, March 25th).

It presents the appearance of a number of more or less fissured crystals, with different degrees of transparency, and with a more or less symmetrical polygonal outline, embedded in a magma of fine-grained silicate. Three varieties of this mineral are described: I). a dark-grey glistening crystalline substance, tabular in form, very opaque, and presenting cleavages indistinctly marking the faces of a prism for which the mean of several measurements gave an angle of $\left\{\begin{matrix}88^\circ\ 35'\\91^\circ\ 25'\end{matrix}\right\}$; II). a colourless transparent variety, which is rare; and III). a grey semi-transparent splintery mineral in very composite fragments. The following additional measurements were made of this mineral:

			Breitenbach enstatite.
100, 110	=	About 46°	... ... 45° 52′
110, $\bar{1}$10	=	87° 10′ to 88° 0′	... ... 88° 15′
100, 101	=	41° 34′	... ... 41° 12′
010, 011 ?	=	About 40°	... ... 40° 21′

The planes 100 and 110 are cleavages. The chemical examination of these three varieties yielded the following per-centage numbers:

	I.	II.	III.			MgO,SiO_2
Silicic acid ...	57·597	58·437	57·037	57·961	57·754	60·000
Magnesia ...	40·640	38·942	40·574	39·026	38·397	40·000
Lime	—	1·677	2·294	1·524	2·376	—
Iron oxide ...	1·438	1·177	0·867	0·154	0·423	—
Potash	0·394	0·332	—	0·569	0·569	—
Soda...	0·906	0·357	—	0·680	0·657	—
Lithia	—	—	—	—	0·016	—
	100·975	100·922	100·772	99·914	100·192	100·000

By acid each variety was acted upon to some extent; the action, however, was found to be simply that of a solvent.

The meteorite also contains a little nickel-iron and schreibersite, having the composition:

Nickel-iron	Iron	94·949
	Nickel	3·849
Schreibersite	Iron	0·884
	Nickel	0·234
	Phosphorus	0·084
		100·000

a very small quantity of troilite, and a small but appreciable amount of chromite, a crystal of which gave the solid angle of a regular octahedron.

The memoir is illustrated with two plates, the one showing very carefully drawn microscopic sections of the augite and enstatite, the other views of the stone and a section of the nodule containing the oldhamite spherules. Plate XI. is an endeavour to reproduce, by the chromolithographic process, a very elaborate water-colour sketch of this interesting stone prepared by my friend Mr. Edward Fielding. On the upper portion of the section towards the right hand is seen the area where the spherules of the calcium sulphide and some large crystals of the augite are situated; below is a pepita of nickel-iron, the occasional white patches indicating large crystals of enstatite.

Found 1853.—Tazewell, Claiborne Co., Tennessee.[1]

This meteorite was one of those selected by the author for his investigation with the spectroscope of the gases occluded by meteoric iron (see also the meteorites of Red River, Texas, and Arva, Hungary). It is noted for the large amount of nickel, 14·62 per cent., which it contains; it had been examined by J. L. Smith,[2] who found no carbon in it. As in the case of the Texas meteorite, this iron appears to evolve gas at ordinary temperatures; the red and green hydrogen lines were brilliant, while the bands of carbon were not noticed. When heat was applied, the spectrum showed the hydrogen lines very brilliantly, and the four chief carbon bands were strongly marked. As the tension of the gas decreased, the hydrogen lines became relatively brighter and the carbon bands grew narrower; and at 1 mm. these bands were still prominent, while some narrow bands apparently belonging to nitrogen were observed. They differed however somewhat, as to the order of their relative intensities, from those observed with nitrogen alone. One of the lines appeared to coincide with the chief coronal line 1474 K, although it was not so sharp as it appears in the solar spectrum. An oxygen line, likewise observed, has the position 1462 K very nearly, and closely agrees in point of refrangibility with a bright coronal line noticed by Denza and Lorenzoni during the eclipse of the 22nd Dec., 1870. A second oxygen line, less bright but sharp and distinct, has the position 1359 ± 1 K. The author directs attention to the complete change which the spectrum of an air-tube undergoes by the introduction of hydrogen. According to the method by which Wright calculates the amount of gas present in an iron (see the meteorite of the Red River, Texas, page 364), this metal occludes 4·69 times its volume of mixed gases. Although the greater part of the gas had been removed, the author is of opinion that the whole amount was by no means exhausted. The fact of the volume of gas in this instance being in excess of that obtained by Graham and Mallet probably arises from the Tazewell iron having been in a finely divided state, and his latest researches on the iron enclosed in the meteorite of Iowa (1875, February 12th) support this assumption.

(To be continued in our next Number.)

IV.—Note on Mr. R. Mallet on the Prismatic Structure of Basalt.

By G. Poulett-Scrope, F.R.S., F.G.S., etc.

Mr. R. MALLET'S paper on this subject, of which an abstract appears in the Proceedings of the Royal Society, as read January 21, 1875, lays claim to a certain amount of originality in the views propounded by him, to which, as well as to the correctness of some portion of them, exception must be taken; though it may be that the conciseness of an abstract will to some extent account for what appears imperfect in its reasoning. For this reason no attempt will be made here to review in detail the general theory announced by Mr. Mallet

[1] A. W. Wright. *Amer. Jour. Sc.*, 1875, ix. 294.
[2] J. L. Smith. *Amer. Jour. Sc.*, [2], xix. 153.

on the cause of the occasional singularly perfect columnar configuration of basalt and other volcanic rocks. It may suffice to say that, so far as the present writer can understand it, as given in an abridged form, it differs in no particular from that which was furnished by himself fifty years back, in the first edition of his work on Volcanos (ed. 1825, p. 135), and subsequently repeated in the second edition of 1862 (p. 96).

On one minor portion of this paper I am however desirous of offering a comment at present, because it involves a mis-statement of fact of some little importance towards the formation of just ideas on the problem in question,—a mis-statement which is quite astounding when it would have been easy for Mr. Mallet to ascertain the truth, and so avoid the error into which he has fallen. It has reference to a portion of Mr. Mallet's theory on which he appears most specially to pride himself as wholly original, viz. that of the formation of those curious cup-shaped or ball-and-socket cross joints, sometimes, but very rarely, found in basaltic columns.[1] "This solution," he says, "is believed to be the first ever presented, which completely accounts for the production of the very remarkable cup-shaped joints." (p. 182, line 22.)

Mr. Mallet's "original" solution of the problem is not very clear; but this is of the less consequence, inasmuch as it is founded on an assumption, or rather assertion, which is untrue, viz. that the convexities of the joints always point in the same direction, away from the surface at which the cooling commenced. In this he is wholly mistaken.

It is the fact that the protuberances are found to occur indifferently in both directions side by side in the same mass of columns; and of this fact Mr. Mallet might have convinced himself any day by simply examining the group of basaltic columns from the Giant's Causeway, which, as a member of the Geological Society, he must have frequently passed in their rooms. This group consists of three columns, figured in Mr. Woodward's paper, page 346, Vol. VIII. of the Geological Magazine. Now it is perfectly evident that in all of these three columns the direction away from the cooling surface at which the splitting commenced must have been the same, and yet in the very upper layer of this specimen the top surfaces of the three columns are alternately convex and concave. Still further, upon removing the first articulation of the left-hand column, it is found to be biconcave, in the fashion of a double-concave lens,—the corresponding convexities pointing of course both ways. So much for

[1] It is remarkable how rare these cup-and-ball-shaped joints in basaltic columns are. They occur, as is well known, in the Giant's Causeway, and at Staffa; though it is by no means common in Scotland or Ireland. It is found in some of the basaltic currents of Central France; see the descriptions and engravings in Abbé Le Coq's admirable work on that district, vol. v. But in Germany, notwithstanding the number and perfect regularity of many ranges of columnar basalt to be seen there, such joints appear to be wholly absent; since I am informed by my friend, Mr. J. W. Judd, at present on a geological tour in that country, that a single joint of the kind from the Giant's Causeway in the Museum at Dresden is the only example known among the German geologists he has met with, and is looked upon as an extraordinary phenomenon.

Mr. Mallet's positive assertion that the "convex surface of a fracture (*i.e.* joint) *always* points in the same direction as that in which the cooling proceeded." That this mis-statement of the fact is not a casual error is shown by further passages, in which (page 183) it is asserted that if the cooling commences from the top surface of the bed, the "convex surfaces of the cross joints *all point downwards;*" whereas if the mass cooled from the bottom, the "convex surfaces of the joints of the lower prisms *point upwards.*" Mr. Mallet's theory, therefore, rests, unfortunately for him, upon a false assumption, which he might easily have ascertained for himself without stirring from London.

Mr. Mallet, however, may perhaps reply that his theory is correct, whether the assumption on which it rests be true or not, since I observe from an article in the latest number of the Proceedings of the Royal Society (162, vol. xxiii. page 444), that he still adheres to his preposterous notion of a Geyser underlying the volcanic vent of Stromboli,—even though it has been demonstrated to him that the steam and water tube required on this supposition must be at least 2000 feet in depth! He takes no notice, moreover, of the many arguments employed by me in the paper to which he refers,[1] against his theory, besides the height of the crater-floor [2] above the sea-level —any one of which is alone sufficiently conclusive as to its untenability.

NOTICES OF MEMOIRS.

Diatomaceæ in the Carboniferous Period.[3]

By Signor, Count, Abbot, Francesco Castracane.

(Translated by Miss L. H. Littledale, Dublin.)

SO great is the importance of Coal, which constitutes the chief wealth of some favoured countries, and is the principal lever of England's power, that no one will wonder that its nature, its mineralogical properties, and the history of its formation, have claimed the attention of scientific men. This valuable substance, in which Nature has preserved to the feverish activity of our century the principal aliment of the metallurgic industry, of arts and commerce, has been the subject of the learned researches of many highly distinguished naturalists and geologists. They have examined the impressions of the many vegetable and animal remains which

[1] Geol. Mag. Dec. 1874.

[2] Bye-the-bye, why will Mr. Mallet persist in calling the bottom of the crater its "*fundus*"? *Fondo* is, no doubt, the word in use for it among Italian writers. But our own language possesses more than one synonym for the thing intended, any one of which would better express the idea to English ears. So, too, in the article on columnar basalt, the French word "couche" is always used by Mr. Mallet in lieu of our native synonyms of "layer," "zone," or "film," all equally expressive of his idea. Other writers, likewise, on volcanic subjects, still continue following the bad example set by Dr. Daubeny, in speaking of a "coulée" of lava, when they mean a "stream" or "current," words equally expressive of a once fluid or flowing mass.

[3] "Le Diatomace nella Eta del Carbone." Extracted from the Atti dell' Accademia Pontificia de' Nuovi Lincei," Rome, 27th year, 3rd session, February 22, 1874.

it contains, and have determined their genera and species; while, by cutting very thin slices of the coal itself, they have been enabled to study, with the aid of the microscope, its texture and minutest ingredients.

These researches did not, however, reveal the presence of some tiny little Diatoms which chanced to be there; thus it has been affirmed that Diatoms were not contemporaneous with coal; a distinguished German naturalist and micrographer having absolutely denied it to the author last summer, placing rather the first appearance of Diatoms at an infinitely more recent period. The only mention which came under my notice of the existence of Diatoms in coal was a quotation from *Acadian Geology* by the distinguished American naturalist, Dr. Dawson, referred to by Professor Huxley in a lecture given by him *On the Formation of Coal.* To prove the assertion that coal is not a subaqueous, but simply a sub-aerial formation, Dawson, amongst other arguments, says that "with the exception perhaps of some *Pinnulariæ* and *Asterophyllites,* there is a remarkable absence from the Coal-measures of any form of properly so-called aquatic vegetation."

On reading that quotation my curiosity was aroused in the highest degree; because, whilst ardently pursuing the study of Diatomaceæ, a strong conviction of their remote antiquity had fixed itself in my mind.

My wishes upon this subject were not influenced by any vain sentiment, but I felt the importance of such an argument in establishing a principle set forth by me on several occasions. Having discovered that in salt, fresh, and brackish waters the Diatomaceæ (together with sea-weeds and vegetables of a higher order) decompose the carbonic acid under the action of the sun's rays, and, assimilating the carbon, set free the oxygen which is the chief and indispensable element in animal respiration; and having experimentally found out that Diatoms, far from sustaining injury from the presence of animal substances in a state of decomposition, rather derive benefit from them—restoring, in short, the water itself to its original state of purity; I deduced from this the inference that in nature the first appearance of Diatomaceæ must have coincided with, if not preceded, the first moments of the existence of the primitive animal inhabitants of the water. The last time I expressed this opinion I added that sooner or later some rocks of Palæozoic age would, without fail, be met with to furnish indubitable proof of the presence of Diatomaceæ contemporaneous with the first animals that lived in the waters. But I was very far from thinking that only a few days after I had uttered this prognostic it would be actually verified. In a small residue collected from the incineration of a fragment of coal (given me as coming from Liverpool), carefully handled and placed for microscopic inspection, my satisfaction may easily be imagined when several Diatoms, perfectly distinguishable, presented themselves in the field of the microscope. In this way I was enabled to prove with all certainty what I had premised, viz. that Diatoms vegetated in the Carboniferous period, that is to say, with the earlier forms of animal life in the *Palæozoic ages.*

In spite, however, of this successful result, obtained by the most scrupulous attention and caution, to avoid the smallest possibility of mistake, I confess that (from perhaps excessive timidity) I hesitated to submit it to public opinion. I therefore resolved to await the result of a contra-proof which I should be able to have by trying again a small remaining piece of the same coal, not omitting to employ on each occasion a perfectly clean test-tube that had never been used before. I need not say what was my gratification at seeing some Diatoms again in the field of the microscope; thus confirming the correctness of my previous experiment. And as a final argument I will add that the forms I recognized and ascertained in the second experiment were either more or less identical with those of the first, so that there could not remain the least doubt of the presence of the Diatoms in *that* coal. Hence it stood proved upon evidence that they must have existed contemporaneously with the plants, the remains of which serve as fuel in furnaces, and give life and motion to the countless steam-engines which make distances vanish and promote commerce. The Diatoms that I met with in this coal chiefly belong to fresh-water genera and species, if we except perhaps a *Grammatophora*, a little *Coscinodiscus*, and perhaps an *Amphipleura*, which appeared to me to be the *A. Danica.* Amongst fresh-water Diatoms I have distinguished the following :—

Fragilaria Harrisonii, Sm. =*Dontidium Harrisonii.*
Ephithemia gibba, Ehrbg., Prz.
Sphenella glacialis, Prz.
Gomphonema capitatum, Ehrbg.
Nitzschia curvula, Prz.
Cymbella scortica, Sm.
Synedra vitrea, Prz.
Diatoma vulgare, Bory.

The influence of the sea, which is shown in the different shapes of salt-water Diatoms (although only single specimens presented themselves among the many fresh-water ones in the residue of the Liverpool coal), offers us an indubitable proof that the waters of the sea must have penetrated amidst the remains of that ancient vegetation.

To account for the presence of those few little marine forms among fresh-water Diatoms, I do not think we can admit the hypothesis that they were merely adventitious, as if carried thither by the wind. Although there can be no reluctance to acknowledge that such a transportation *could* take place, yet I do not find it possible to persuade myself that some valves of marine Diatoms which have been now and then detected in the atmospheric dust, may be precisely encountered amongst a small number of fresh-water Diatoms. It is to be added, moreover, that I do not remember ever having met with a notice of marine Diatoms being found in the atmospheric dust, whereas fresh-water forms are often spoken of.

It is truly an easy thing to understand how at the drying up of a pond the wind may sweep away from the surface the minute siliceous skeletons of Diatoms which have been growing there for generations; but one could not so readily understand how the same could happen to those of the sea. However, the fact that at the very remote period of the coal formation Diatoms lived and formed a part of its flora, offers us, it appears to me, a most valuable opportunity of making an observation of much greater import.

However little any one may be accustomed to the contemplation of nature, it is easy to recognize how the various organic types can to a certain extent be modified by the influence of climate and other circumstances under which they are living. Nevertheless, the effect of such influences is so much less perceptible, and the consequent modification so much slighter in proportion as the type occupies a more elevated position in the organic scale. Now, although, when disserting last year upon the structure of the Diatoms, and the various parts and substances which compose them, as well as the marvellous ornamentation to be admired in their valves, I allowed myself to be carried away by enthusiasm for these wondrous organisms, so far as to say[1] that "the Diatoms, far from being such humble little plants as to deserve banishment among the lowest organizations of the Vegetable Kingdom, have a far better right to be looked upon as forms as noble in their structure and perfect arrangement as they are marvellous for their minuteness," it is nevertheless true that, *organically* considered, they must be acknowledged simpler than and therefore inferior to the humblest mosses and vascular plants. Nevertheless, who could have expected (on the supposition that Diatoms have been growing from the time of the first dawn of life upon the earth, in such enormously long evolutions of centuries, and in the succession of ever new states of temperature and climate) that they would not at least have been greatly changed? All the forms I have been able to observe amongst the few ashes of the before-mentioned coal present such an appearance that the most practised and sharpest eye could not detect the slightest difference between them and actually living Diatoms. In outline, structure, shape and number of the flutings,—in short, in all the peculiarities which characterize the species that we meet with in a state of actual vegetation,—the Diatoms of the Carboniferous and Palæozoic periods agree exactly. In such immeasurable succession of centuries, organic life under this most simple and primitive form since its appearance upon the globe (notwithstanding the tremendous catastrophes which have altered the condition of its surface) has not experienced the slightest change, and remains unaltered up to our day: so true is it that upon each organic type Nature has imposed an immutable law which restrains it within its own limits.

But the successful result I obtained from the examination of the Liverpool coal, and the discovery of Diatoms contemporary with its formation (thus conclusively proving the existence of Diatoms in the Palæozoic epoch), revived my desire to institute a similar research through coal from other sources. Otherwise it might be questioned by some whether the Diatoms found in the chip of Liverpool coal had not simply adhered to it by accident, without being contemporary with its formation: as it might happen that Diatoms should

[1] See my note "On the Structure of Diatoms," Atti dell' Accad. Pont. dei Lincei, Anno 26, 19 Gennaro, 1873.

accidentally be discovered upon the surface of granite, or any other older rock, without any one assuming that they grew in the period of the granite's formation.

Such objections did actually occur to my mind; they lost all force, however, by the reflection that the scrap of coal upon which my examination had been made came out of the solid mass of that mineral, and not from off the surface; besides, the piece from which it was detached is preserved in the Mineralogical Cabinet of the "Sapienza" in Rome, and thus the discovery made by me may be controverted by other people at any time.

These examinations are rendered easy to me from the special arrangement of my microscope, which is such that it enables me to be sure of having examined in turn each point of the entire substance, giving me, besides, leisure to mark the position of the smallest form whatsoever, in order to be able to find it again at any moment. After having fully determined the fact of the presence of Diatoms in the Liverpool coal, I resolved to ascertain whether the same could be detected in coal from other sources. With this intention I have up to the present time made analogous investigations upon three other samples obtained from the before-mentioned Mineralogical Cabinet. One is from the mines of St.-Etienne, another came from Newcastle, and the third was a fragment of the so-called "cannel-coal" of Scotland. Not a single one of these different substances failed to reveal Diatoms in greater or less numbers. Of these I did not remark any that were not fresh-water; nevertheless the species varied in each. The forms I found did not give me occasion to note any novelty whatsoever, while there was not one among them of which I would have hesitated in declaring that it was a living form. Thus the presence of Diatoms (which seemed to me such a great fact to have been able to prove in the Liverpool coal) showed itself persistently in the three other different kinds, so that I begin to suspect that *perhaps* Diatoms accompany every stratum of coal.

From the presence of Diatoms in coals not only does the principle established by me of the necessity of Diatoms in water to maintain animal life stand confirmed, but we have a new subject of study in recognizing the highly important part which Diatoms and microscopic life have ever played upon the earth.

From all this arises the necessity of the geologist directing the greatest attention to whatever traces remain to us of these minute beings which had so much share in the history of the globe.

I am encouraged to hope that these observations of mine, or at least the fact proved by me of the presence of Diatoms in coal, will not be regarded as undeserving attention by some geologist or micrographer. It will be most gratifying to me if my remarks and experiments, under the direction of some more competent person, prove any advantage to science. In that case, in order to facilitate the task still more to any one less expert who may wish to undertake such an examination, I shall add a hint as to the process followed by me in conducting these researches. The course to pursue is decided by the flinty nature of the Diatom-valves, and in order to separate them from the mixture of calcareous or organic matter with which they are found united, it is usual to put the whole into a glass test-tube with hydrochloric acid, adding caustic potash from time to time, keeping all slowly dissolving by heat, in order to isolate the silex, destroying the remainder. But in unburnt coal it is too difficult to dislodge the carbon, and the acids have little effect upon it. I must, however, refer to the calcination I effected by grinding up the substance, and then, collecting it in a china vessel, placed upon a stove in a glass tube, subjecting the whole to the action of the heat, while, at the same time, a slight current of oxygen crossing the tube combined with the carbon in creating carbonic acid.

Experience has taught me, however, the necessity of conducting this operation at a lower temperature, in order to prevent the alkaline or earthy bases and metallic oxides, which may be amongst the ashes, from forming vitreous silicates by melting and mixing with the valves of the Diatomaceæ. It is also well to leave the glass tube, in which the fusing is going on, uncovered, in order to watch its progress. The small residue obtained through this process is to be put into a clean test-tube, adding nitric acid and hydrochloric acid, and caustic potash, assisted by the heat of a lamp to eliminate any alkaline or earthy base, and every trace of metallic oxides. The last operation over it only remains to wash repeatedly with distilled water the very light dust which is left behind, letting it stand for some hours each time to settle, in order to be sure of not losing the smallest particle of it in pouring off the water.

Those who follow this method exactly cannot fail to succeed. The object may then be mounted with Canada Balsam, or in any other suitable medium: and steadily and closely watching it under the microscope, they will not be long before they see some valves of Diatoms, entire or broken.

If any investigator wish for fuller information, I shall have great pleasure in gratifying him, and will consider myself honoured by his applying to me.

REVIEWS.

I.—An Abstract of the Geology of India. By Prof. P. M Duncan, F.R.S. (London, 1875.)

THIS Abstract is a useful addition to geological literature. Without any pretension to a general treatise on the subject, and consisting merely of geological facts, with no sections or illustrations, it is intended as a text-book for the students of the Indian Civil Engineering College, where Geology is fortunately recognized as a necessary part of their education, and as an advantage to their future career. The late Mr. Greenough had collected a vast amount of material, which he used in preparing his large geological map of India in 1854, a reduced copy of which, with notes, appeared in 'Petermann's Geogr. Mittheilungen' for 1855. But this knowledge has been considerably increased by the subsequent labours of Carter, Drew, Strachey, Falconer and Cautley, D'Archiac and Haime, as well as by the valuable Memoirs and Reports of the Geological Survey under the direction of Dr. Oldham, the result of the arduous and exhausting labours of himself and colleagues in the field-work of the Indian Survey. In this Abstract the geology of India is considered under two heads,—the Himalayan and Peninsular types; the former comprising the Himalaya, the Salt-range, the hills on the west of the Indus to the sea, and the great alluvial districts through which the Indus and Ganges with their tributaries flow; the references to this district are nearly restricted to the details of the Himalayan and Indo-Gangetic area. The Peninsular province is bounded on the north-west and north-east by the alluvial plains, and elsewhere by the sea. The successive geological formations, when they occur, are treated of in descending order in the above two provinces, and thus their differences and resemblances may be compared; but the same formations are not invariably present in both geological provinces, and it appears that the remains of former land surfaces are much more common in the Peninsula than in the Himalayas, where the marine deposits preponderate.

There are many interesting and peculiar points of Indian geology concisely described, as to their occurrence and origin, such as the "Rigar, or cotton soil," the Kunkur and Laterite. The Sub-Himalayan rocks are noticed, and also their rich mammalian fauna, so ably described by the late Dr. Falconer and Major Cautley, who obtained the bones from the Sivalik strata occupying many thousand feet in thickness, and also from the Nahum series, both of Miocene age, and which include remains of Primates, Carnivora, Proboscidea, Ruminantia. The Monkeys are all old-world types, and in all probability there is no satisfactory specific distinction between the forms and the recent species of Asia. The Loxodons are allied to the African elephant. Hippopotamus, no longer Indian, is an African form, and the Cameleopards are African in their present distribution. The Sivalik fauna had therefore Asiatic and African members; and whilst the majority of its species are extinct, many exist at the present day in India. In the Peninsular province the Malwa and Deccan traps occur; they are post-Cretaceous, of great thickness, and form a very important feature in the geology of India, for they extend over 200,000 square miles of Western and Central India, and formerly covered a much larger surface, as they have suffered from denudation. In this province also is the Damuda Coal-bearing series, which, with the sub-divisions and plants, are fully noticed at pp. 44–48; and a detailed account is given of the five zones of rocks of which the Himalayas appear to be formed, as derived from the sections given by Medlicott and Stoliczka.

Most of the chief European strata appear to be more or less fully represented by equivalent formations, with the exception of the Cambrian, Devonian, Carboniferous Coal, Lower Oolite, and Neocomian. The oldest fossiliferous rock is referred to, the Bhabeh series or Lower Silurian, which may be newer than an important formation called the Vindhyan, of unknown age, and which occupies a very large area in the North-west and Central provinces, and probably occurs in the neighbourhood of Madras. From this series the finest building and ornamental stones of India are obtained, chiefly in the upper or Bundair group; but the lower or Kymore sandstones are also extensively worked, especially at Chunar.

Although intended merely as notes of reference for the student of Indian geology, the general geological reader will find it of some interest as comprising our present knowledge of Indian geology, and in comparing it with that of the European area, for which purpose a table of the presumed equivalent formations is given, which, although showing a general similar succession of formations, may not represent the synchronism with European strata, "for it must be understood that the term *equivalent* does not infer synchronism or contemporaneity. It appears that some forms of life existed earlier in India than in the European area, and this, taken with the fact of the occurrence of the same species in the distant strata, requires the inference that time elapsed during a migration or a natural distribution."

This Abstract is alike creditable to Prof. Duncan and to the authorities under whose auspices it has been published. J. M.

II.—Eléments de Géologie et de Paléontologie. By Ch. Contejean. Paris, 1874. 8vo. pp. 745 (467 Woodcuts).

IT is by means of the higher class of text-books to which this work belongs that we are kept posted up in the progress in other countries of Geology as a whole. It is seldom, however, that a manual presents so many points of contrast with its forerunners, nor, it may be added, so many signs of advance, as Prof. Contejean's *Eléments.* French Geologists, though frequently of the deepest *red* in politics, have always been extreme Conservatives in their special science. They have in many cases shown a degree of deference to mere authority in scientific matters which we can scarcely match in the annals of British Geology. In no instance has this deference been more marked than in the all but universal acceptance of the late M. Elie de Beaumont's "Pentagonal System." To this theory we owe the collection of so large an accumulation of valuable stratigraphical facts, that it seems almost ungrateful to say that it is refreshing to see in Prof. Contejean's book not only a very fair *résumé* of the famous system, but also a very full and complete refutation of it, comprised altogether in some twenty pages of close print. We, in England, who have never been caught in the great Pentagonal net-work, are hardly able to appreciate the importance of so clear and able a statement of the insuperable objections to it, coming, as this does, from a man holding an acknowledged position in the professorial hierarchy of France. Truth will out, as we all know, but due honour should be given to those who help the most vigorously to draw her out of her well. This Prof. Contejean is distinctly doing by means of his new manual.[1]

[1] It may be well to mention that Prof. Contejean's book was published just before M. Elie de Beaumont's lamented death.

Five-sevenths of his book deal with Physical Geology, the historical portion being very briefly, and it may be somewhat inadequately, treated, although it is illustrated by some 350 capital cuts. It is only fair to the author to say that he looks upon Palæontology, on principle, as an auxiliary science only, and not, as too many writers of text-books would appear to do, as the main end and object of Geology.

In the account of the various great geological stages, the author scarcely does justice to his advanced views when he retains, even apologetically, so misleading a term as '*Epoque de transition*.' In including the Coal-measures in the *Terrain Carbonifère*, on the other hand, good service is done, since the custom of limiting the application of this term to the Carboniferous Limestone Division is one much on the increase among French geologists, and one fruitful of misunderstanding.

Restorations of fossil vertebrates are confessedly to a certain extent hypothetical, but even with this reservation it is difficult to believe that the Megalonyx was really quite such an extraordinary beast in the flesh as he is represented in fig. 464, or that the body of the Pterodactyl was clad in particoloured scales like a serpent!! fig. 347—almost the only two illustrations in the book to which exception can be taken, the rest being, when new (as many of them are), of a high order of excellence, and when otherwise, chosen from the best among old friends.

That the physical division of his work is up to the present state of knowledge will be seen when it is said that Dr. Carpenter's latest dredgings, that Mr. Croll's "Excentricity" results, and that the current theories of both are utilized by M. Contejean. Indeed, the list of authors quoted which precedes the copious Index is a sufficient proof that the oft-repeated, and not altogether undeserved, accusation that French men of science are apt to ignore foreign work, does not apply in any degree to the author of this manual of Geology.

G. A. L.

REPORTS AND PROCEEDINGS.

Geological Society of London.—June 9th, 1875.—John Evans, Esq., V.P.R.S., President, in the Chair.—The following communications were read:—

1. "On *Prorastomus sirenoïdes*, Owen. (Part II.)." By Prof. Owen, C.B., F.R.S., F.G.S.

The author has submitted the skull of a Sirenian from Jamaica, described by him in 1855 under the name of *Prorastomus sirenoïdes*, to a careful re-examination; and in this paper notices the characters revealed by further removal of the matrix, and discusses the bearings of the facts thus ascertained upon the relations of the animal and of the Sirenia generally. The parts which have been brought to light are the base and roof of the cranium, the zygomatic arches, the hind half of the mandible, with the articular part of the condyle, and the greater part of the atlas. The characters presented by these parts are described in detail, and the characters of the genus are compared with those presented by other genera of Sirenians, both living and fossil, especially *Manatus* and *Felsinotherium*. The dental formula of *Prorastomus* is given as:—

$$i. \frac{3-3}{3-3?},\ d. \text{ or } c. \frac{1-1}{1-1},\ p. \frac{5-5}{5-5},\ m. \frac{3-3}{3-3} = 48;$$

thus, as in *Manatus*, showing an excess in the molar series over the type of the terrestrial herbivorous mammalia, whilst the incisors and canines retain the common type as to number and kind, and have not been subjected to so great a degree of suppression or of individual excess of development as in existing Sirenians. The presence of these small subequal incisors in both jaws of *Prorastomus* is the most marked feature in which *Prorastomus* adheres to the normal mammalian type, while showing the essential characters of the marine Herbivores; but a similar tendency is shown in other parts of the skull.

The author regards the Sirenia as essentially monophyodont. *Halicore* and *Felsinotherium* depart further from the type than *Halitherium* and *Manatus*, and these than *Prorastomus*. *Rhytina*, with a better developed brain, and with the jaws edentulous when adult, is an extreme modification of the Sirenian type. The rudimentary femur in *Halitherium* is to be regarded as the result of degeneration through lack of use, from better-limbed prototypal mammals.

With respect to the genealogy of the Sirenia, the author remarks that Häckel derives the Sirenia, Zeuglodontes, and Cetacea, together with the Artiodactyla, from the branch Ungulata, and the Perissodactyla from the branch Pycnoderma of the Mammalian trunk; but that while *Halitherium* and *Felsinotherium* show the molar pattern of *Hippopotamus*, *Prorastomus* exhibits that of *Lophiodon* and *Tapirus*, to which *Manatus* also adheres, rather than to any Artiodactyle type. The author suggests that both Ungulates and Sirenians diverged at some remote period from a more generalized (Cretaceous?) mammalian gyrencephalous type; and that the marine Herbivora in the course of long Eocene and Miocene eons were subjected to conditions producing modifications of their molars, leading on one side to an Artiodactyle and on the other to a Perissodactyle character. As *Prorastomus* by its more generalized dentition and shape of brain represents a step nearer the speculative starting-point than any other Sirenian, it acquires a great interest, and the determination of the precise age of the (supposed Eocene) bed from which its remains were derived is very much to be desired.

2. "On the Structure of the Skull of *Rhizodus*." By L. C. Miall, Esq., F.G.S.

In this paper the author described a large skull of *Rhizodus* from the coal-shale of Gilmerton, near Edinburgh. The characters described show that *Rhizodus* is a Ganoid fish, and that its position in the order is not far from *Holoptychius* and *Megalichthys*. The author referred it to the cycloidal division of the family Glyptodipterini.

3. "Appendix to a 'Note on a Modified Form of Dinosaurian Ilium, hitherto reputed Scapula.'" By J. W. Hulke, Esq., F.R.S., F.G.S.

This paper contained a notice of the pubis of *Iguanodon,* which proves to be identical with the smaller of the two specimens figured by the author in a former paper (Quart. Journ. Geol. Soc. vol. xxx. pl. xxxii. fig. 1). When inverted, its long slender process is easily identified with that of the pubis of the nearly allied *Hypsilophodon,* and this slanted downwards and backwards parallel to the ischium, the little process of its posterior surface meeting a corresponding process of the ischium, and converting the upper end of a long narrow obturator space into a foramen. The pubis of *Iguanodon* contributed largely to the formation of the acetabulum, thus resembling that of existing Lacertilia, as also in its possession of a broad ventral extension, probably united with that of the opposite side by a median symphysis. The specimens described in this paper were collected in the Isle of Wight by the Rev. W. Fox.

4. "Notes on the Palæozoic Echini." By Walter Keeping, Esq., of the Woodwardian Museum, Cambridge. Communicated by Prof. T. M'Kenny Hughes, F.G.S.

The author alluded to the interest excited by the discovery of Echinoderms with flexible tests; and having pointed out the difference between the more modern and the Palæozoic forms (their plates imbricating in opposite directions), gave a description of the following forms:—I. *Perischodomus.* II. *Rhœchinus,* g. n., sp. *R. irregularis* (Keeping). III. *Palæchinus* (?) *intermedius* (Keeping). IV. *Palæchinus gigas* (M'Coy). V. *Palæchinus sphæricus* (M'Coy). VI. *Archæocidaris Urii* (Fleming). In conclusion, the author proposed a new method of classification for the *Echinoidea.* He also noticed the existence in the Museum of the Royal School of Mines of a British fossil which appears to belong to the group of Echinoidea with numerous ranges of ambulacral plates, represented in America by the genera *Melonites, Oligoporus,* and *Lepidesthes.*

5. "On some Fossil Alcyonaria from the Australian Tertiary Deposits." By Prof. P. Martin Duncan, F.R.S., V.P.G.S.

In a former communication in 1870 the author described some fossil corals from the Tertiary strata near Cape Otway, in the province of Victoria. In one, which he called the "Upper Coralline bed," the equivalent of the Polyzoan limestone of Woods, he found specimens which he did not then describe, as they were not true corals. Belonging to the Isidinæ, and not being of great interest, he retained them until the receipt of some similar specimens from New Zealand, described in the following paper. The Australian forms described by the author were shown to be nearly allied to the recent *Isis hippuris* and the fossil *I. corallina.*

6. "On some Fossil Alcyonaria from the Tertiary Deposits of New Zealand." By Prof. P. Martin Duncan, F.R.S., V.P.G.S.

The New Zealand fossils referred to in the preceding paper were sent to the author by Capt. F. W. Hutton, F.G.S.; they were derived from the Awawoa Railway cutting, and were from the upper part of the Oawaru formation. They consisted of fragments of species of the genus *Isis* and of *Corallium*. These were compared with those from the Australian Tertiaries, and the author inferred that both deposits were formed under similar conditions, and that they were at least homotaxial, whatever their precise geological age might be.

7. "On some Fossil Corals from the Tasmanian Tertiary Deposits." By Prof. P. Martin Duncan, F.R.S., V.P.G.S.

The author described a new species of *Dendrophyllia* possessing very unusual characters, the epitheca replacing the true wall, and giving the specimen a marked Palæozoic appearance. The fossil was obtained from a Tertiary deposit, and was associated with *Placotrochus deltoideus*, a well-marked coral, characteristic of a definite geological horizon in Victoria, namely the lower beds of the Cape Otway section, belonging to the Lower Cainozoic period. For this coral he proposed the name of *Dendrophyllia epithecata*. A much worn reef-coral was found associated with the above.

CORRESPONDENCE.

ON THE NOMENCLATURE OF ROCKS.

Sir,—In "A Handy-book of Rock Names" it was suggested that some of the rocks therein included as granitoid varieties of Liparite "ought probably to be classed among the granitic rocks."[1] This opinion seems also to be shared by Mr. J. W. Judd, F.G.S., as in his lately published description of the Ponza Islands,[2] he particularly mentions the granitoid rocks of that island and certain others in the Euganean Hills, Hungary, etc., which he considers to be of the same class as the North American rocks, for which Richthofen has suggested the name Nevadite, or granitic-rhyolite. If we accept this name, we add to our granites:

Nevadite (Richthofen), a granitic rock, having a more or less crystalline felsitic matrix, inclosing crystals of quartz, one or two felspars (orthoclase and albite or oligoclase), mica or amphibole.

This granitic rock represents the passage rock between trachyte and normal granite; similarly, as a siliceous elvanite, among the older rocks, is the passage rock between felstone and normal granite. There has, however, still to be discovered and described, the passage rocks between augite and granite; and such rocks I suspect to exist in the neighbourhood of Carlingford Lough, Ireland (parts of Cos. Armagh, Down, and Louth). In this area my colleague, W. A. Traill, has found either four or five distinct intrusive granites: first, Newry granite of pre-Carboniferous age; second, Mourne granite of post-Carboniferous age; third, elvanite, probably of the same age as the Mourne granite; and fourth and fifth, granitic rocks, possibly of Tertiary age. The latter rocks seem principally to occur in the Carlingford district on the south of the Lough, and are variable in character; some being similar in aspect to some of the typical elvanites; while

[1] A Handy-book of Rock Names, p. 71. London, Robert Hardwicke, 1873.
[2] Geol. Mag. July, 1875, p. 298, et seq.

others are more or less coarsely crystalline rocks, in which pyroxenic minerals usually predominate. These rocks are protruded in larger or smaller masses, and allied to them are dykes of a maculated basic rock, one of the hybrid rocks of Durocher. These dyke rocks are very undecided in composition, and in places may be classed as dolerite, while in others they must be called either Felstone or Trachyte. These maculated rocks seem to graduate into Dolerite and Augite, similar to and probably of the same age as the Tertiary dolerites of the Co. Antrim. A typical elvanoid rock belonging to one of these groups (fourth or fifth) occurs at Goragh Wood (where it is extensively worked), coming up as a mass through the older Newry granite. This rock would answer the description for Nevadite, and possibly may be one of the granitic rocks belonging to the trachytes of Antrim. The rocks in the country about Carlingford Lough at present are only partially known; this, however, ought not to be for long, as they have been carefully examined by Mr. Traill.

In conclusion, I may mention that in the Mourne district to the north of the Lough, Mr. Traill found some of the dykes similar to and probably of the same age as the maculated dykes of the Carlingford district, that at their margins suddenly changed into a vitrioid rock, locally called Bottleite, that when examined by our colleague, F. Rutley, F.G.S., was pronounced to be Trachalite. This trachalite in places assumes a fibrous structure, apparently somewhat similar to that described in the obsidian of Ponza by Judd, and from fibrous it seems in places to pass into a minute columnar structure, the rock at the same time changing into anamesite or basalt. Judd seems to be of opinion that this fibrous structure is due to extreme pressure; with this I cannot agree, as it may occur in places where the dykes evidently occur filling shrinkage fissures. Many, indeed most, fibrous varieties of minerals and rocks, seem to be due to crystalline structure, the substance being deposited from solution; this, however, is not always the case, as in some instances the process seems to have been somewhat similar to drawing out heated glass into hairs. Such, however, could scarcely be due to pressure, and in many places where observed it looks as if the foundations of the dyke had given way, and that films between the consolidated portion of the dykes, or one of its walls, had been drawn out while the dyke was sinking.

Wexford. G. H. Kinahan.

GLACIAL EROSION.

Sir,—There are some points in Mr. Goodchild's interesting communications on Glacial Erosion (Geol. Mag. pp. 323, 356), concerning which I should like to make a few remarks. As I have not the advantage of much knowledge of the principal district which he describes, I cannot attempt to discuss them in detail, but as most points in his description appear to me to be common to all similar districts that I have seen, I venture to offer two or three general criticisms.

He objects (p. 328) to the theory which attributes the formation of rock ledges mainly to fluviatile action, because of (1) their height above the present level of the existing streams; (2) the general parallelism of the scars on opposite sides of the valleys; (3) the persistence of the peculiarities in form due to the nature of the bed. But with regard to these objections, I may remark that, so far as my memory serves me, they would hold in every hilly district that I have seen, where bedded rocks of a similar character exist, whether the district has been exposed to glacial action or not; also that it is no uncommon thing to see a river valley, with nearly flat bed, far wider than the existing stream. In some cases these may be explained by the volume of the stream being formerly greater, as it no doubt was occasionally in past history; in others the slow motion of the river from one side of the valley to the other would suffice. Further, that if a configuration were once given to the banks of the valley, and these were afterwards cut back in tolerably homogeneous rock by *aerial* denudation only, the original form would still be generally preserved, because the recession would be approximately uniform throughout. These phenomena are to be seen in the valleys of the Alps and the Jura, and if he is prepared to attribute these *mainly* to glacial erosion, he must get over some objections to which I will presently refer.

Is it necessary that swallow-holes should be formed by streams? Of course streams may form them—witness Gaping Gill; but I have seen districts riddled by swallow-holes, as the "Stony Seas" of the Eastern Alps, which were evidently formed by the rain drainage of a very small area. Some of those also in the Chalk have, I think, been simply dissolved out by the subterranean drainage of a very limited basin. The formation of a swallow-hole, I think, mainly depends on the nature of the rock. I have, however, seen in the Alps swallow-holes which have been modified by the erosive action of the streamlet.

The large amount of debris supposed to have existed on the surface before the Glacial Period seems to me an assumption. Many parts of the great insular mass of crystalline rock in Central France had almost certainly not been under water from a very remote epoch, a large portion of it certainly not since Miocene times; yet there is no great amount of surface debris here, and I suppose we may dispense with an ice-sheet for Auvergne? Surely also, as soon as a layer of a few feet of debris had formed on the surface, it would greatly protect the rock beneath from all agencies but those of percolating water? Again, with regard to Mr. Goodchild's explanation of the absence of ice-marks from the higher parts of mountains (p. 360). If a glacier is an erosive agent of such power, as he supposes it to be, a very limited duration of contact with the upper rocks ought to suffice for imprinting its "handwriting on the wall." Thus, making every allowance for greater exposure to weather, we ought now and then to find the blurred remnants of these inscriptions. I have climbed more than most men in the regions of glaciers, but never saw them. To my eyes the transition from weather-worn to ice-worn rocks appears usually rather abrupt, and at a regular height.

Finally is there evidence at all that glaciers possess this immense erosive power? I have shown (Quart. Journ. Geol. Soc. xxvii. 312; xxix. 382; xxx. 479) that in several districts of the Alps there is evidence that the glaciers have descended important valleys, filling them almost down to the level of the present torrents, yet have been incompetent to modify their principal features, which are most characteristically those of fluviatile erosion. This argument, I venture to assert, has never been met. Every year that I travel gives me fresh instances, and during the present summer I have met with one or two other curious facts bearing on the subject of glacier erosion, which I hope to be permitted to lay before the readers of this Magazine in a month or two.

I have thus ventured to indicate some of the reasons why Mr. Goodchild's arguments fail to convince me. If they seem rather curtly stated, I must ask him to believe it is because I am trying to discuss in a letter a subject which requires a lengthy article.

T. G. Bonney.

St. John's College, Cambridge, *Aug. 9th*, 1875.

THE POST-PLIOCENE FORMATIONS OF THE ISLE OF MAN.

Sir,—Will you kindly allow me space for a brief rejoinder to the articles by Mr. Horne and Mr. Kinahan in the July Number of the Geological Magazine?

1. Allowing, as Mr. Horne says, that intercalated beds of sand, gravel, etc., are of common occurrence in the Lower Boulder-clay, still I cannot see that this entirely destroys the force of the argument *à priori*, that they would probably be of more frequent occurrence in a deposit like the Upper Boulder-clay, which was formed when the cold was less severe, and warm seasons oftener to be expected; and therefore that the highest beds in the Isle of Man, which Mr. Horne considers Lower, are, so far, more likely to be Upper Boulder-clay.

2. Although it may be true that the glaciers of the post-submergence period were confined mainly to the upland valleys, and therefore that moraines *might* be all the memorials to be expected of them, still the *sea*, both before and after the second continental period, must have contained ice in sufficient quantity to produce a thick deposit of clay, such as in Lancashire, for example, is found extending from an elevation of above 1000 feet to the cliffs on the sea-coast (see Geol. Survey Map 91); and it was principally to marine coast-ice, and not to glaciers, that I attributed the Upper Boulder-clay in the Isle of Man.

3. No doubt Mr. Horne is right as to the general characteristics of Lower Boulder-clay in South Scotland, viz. that it is a tough clay with an abundance of ice-marked stones, without stratification, and without shells. But even this true Lower Boulder-clay, or Till, varies according to the nature of the rocks from which it is derived, and it was with the Lower Boulder-clay as it appears in the cliffs at Blackpool, and not in Scotland, that I compared the deposits which I have taken to be such around the point of Ayre. If, however, they should prove not to be Lower Boulder-clay properly so called, nor

one of the intercalated beds with sand and gravel, they might at least easily be a portion, probably a lower portion, of the Middle sands and gravels, and so still the lowest Post-Pliocene formations in the island.

It seems, from what I have learnt from Mr. Horne's and Mr. Kinahan's papers, as if there was a different division of the glacial series recognized by some geologists in Scotland and Ireland, from that adopted by the Geological Survey for the north-west of England; the former consisting of

1. Lower Boulder-clay.
2. Upper or Moraine Boulder-drift.
3. Kame or Esker Drift.[1]

the latter of

1. Lower Boulder-clay.
2. Middle Sands and Gravels.
3. Upper Boulder-clay.

and it would certainly be a point of some interest to determine to which order, or if to either, the Post-Pliocene deposits of the Isle of Man conform. But I think this must be decided by stronger evidence than that of the section at the southern end of the island to which Mr. Horne refers, and with regard to which his words admit of a double doubt—first, whether the underlying formation is really an Upper Boulder-clay, and not a Lower; and secondly, whether the clay with shells there is certainly identical with the shelly clay in the north. It must be decided, if not by direct evidence of superposition, at least by further probable evidence of such superposition, and also, as far as possible, by that of Molluscan contents. Do the shells of the Isle of Man deposits resemble more those of the Blackpool Middle sands and gravels, or those of the Clyde and Forth basins (of a more Arctic[2] character), with which Mr. Horne identifies these beds? With regard to Mr. Horne's lithographed section, it seemed to me, though on slight evidence, when on the spot, rather as if the red clay of the north of the island, in the bed of the Ballure stream, passed *under* the clays and gravels which the lithograph represents as Lower Glacial.

In answer to Mr. Kinahan, I need only say that I have used the term "Glacial Drift" in the sense in which I find it used (or at least language which implies such a use of it), by the highest authorities from Forbes till now, that is, of Drift formed whether by ice alone, or by ice and sea together (*i.e.* Marine Glacial Drift), *during the Glacial Epoch.* No doubt much glacial drift in all ages, including that of its first formation, has been reconstructed in the manner explained by Mr. Kinahan, but, with deference to him, it is difficult to believe that extensive deposits like the Middle sands and gravels, and the Upper Boulder-clay (in Lancashire and Cheshire), have altogether or chiefly, been formed in this way. These would still seem

[1] Mr. Kinahan and Mr. Horne identify these with the Middle or "Marine" (Irish) gravels, though I had been led to believe that the difference between them was sufficiently marked by the presence of shells and chalk-flints in the latter, and their almost entire absence in the former. (See. GEOL. MAG. Dec. 1869, p. 544.)

[2] See GEOL. MAG. Dec. 1869, p. 548.

to be attributable rather to icefloes and icebergs and to coast-ice and glaciers depositing their moraines in the sea; and therefore would properly come under the description of Marine Glacial Drift.

Drift, however, which has been reconstructed *since* the Glacial Epoch could not of course be considered glacial, but would perhaps be appropriately distinguished as "glacialoid."

The question, however, of the nomenclature of Glacial Drift is quite beside that of the *order* of the deposits at present understood by that term.

I regret that I should seem to have misquoted Mr. Kinahan's letter; but I think, for I have not the Numbers of the Geol. Mag. at hand, he must have misunderstood me, as I was quite aware that he admitted an Upper Boulder-clay in Ireland, but not one *above* the Middle gravels, which was the only one to which I referred.

J. A. Birds.

Tenby, *Aug.* 3*rd*, 1875.

OBITUARY.

PROFESSOR G. P. DESHAYES,

For. Memb. Geol. Soc. Lond.

Gerard Paul Deshayes was born at Nancy, 13th May, 1797, his father being at the time Professor in the Central School of that city. He was educated at Strasbourg, and came to reside in Paris in 1819, where he commenced the study of fossil shells, for which in after years he became so justly celebrated.

Among other foreign explorations, he visited Algeria, and subsequently published the results of his expedition in a work remarkable alike for the beauty of its illustrations, as well as for its high scientific value.

A careful study of his extensive collections of Tertiary shells (greatly facilitated by his intimate acquaintance with recent species) had suggested to Deshayes the propriety of dividing them chronologically into three great groups, according to their relative ages. These groups were found to agree, in the main, with the divisions arrived at by Lyell, and to which he subsequently gave the names of Eocene, Miocene, and Pliocene. To give weight to this classification, Lyell induced Deshayes to prepare a series of tables, which appeared in the third volume of the first edition of the "Principles," in 1830.

Deshayes' collections served as the basis of his great work, "On the Fossil Shells of the Environs of Paris" (published from 1824–37, and the subsequent supplement extending from 1856 up to 1867), forming eight great quarto volumes. He published an Elementary Treatise on Conchology; and he revised, with Professor H. Milne-Edwards, Lamarck's Histoire des Animaux sans Vertebres, and Ferussac's Histoire des Mollusques Terrestres et Fluviatile. He prepared the Catalogue of the *Veneridæ* for the British Museum. He also published numerous Memoirs, both separately and in various scientific journals.

M. Deshayes was one of the original founders of the Geological Society of France, of which he was several times President. The decoration of the Legion of Honour was conferred upon M. Deshayes in 1837.

His fine collection of Tertiary fossil shells was purchased by the French Government for £4000, and is now preserved in the Museum of the École des Mines, Paris.

M. Deshayes was appointed in 1869 to Lamarck's Chair of Natural History in the Muséum d'Histoire Naturelle.

So long ago as 1841, Prof. Deshayes was elected a Foreign Member of the Geological Society of London. On three occasions (1836, 1856, and 1864) the Geological Society awarded M. Deshayes the proceeds of the Wollaston Donation Fund, to assist him in his long-continued researches; and shortly after their completion, in February, 1870, they awarded him the Wollaston Gold Medal, "as an expression on the part of the Society of the high estimation in which his services to Palæontology and Geology, especially in regard to the classification of the Tertiary formation, are held by the the geologists of this country."[1]

Perhaps the highest commendation of Prof. Deshayes (from one who was intimately acquainted with him for many years) is that he "found him always desirous to communicate all the information in his power to those who asked it from him."[2]

M. Deshayes died on the 9th June, 1875, in his 79th year.

WILLIAM JORY HENWOOD, F.R.S., F.G.S.

Another veteran in the great army of Science has been lost to its ranks; one whose contributions to mineralogy and whose acquaintance both with the theory and practice of mining and the mode of occurrence of mineral veins has made his name known and respected by both scientific men and miners all over the world.

William Jory Henwood, born at Perron Wharf on the 16th July, 1805, was the son of Mr. John Henwood, sprung from an ancient Cornish family at Levalsea in St. Ewe. His father, like many others, had lost largely by his connexion with the first Cornish Silver mine, the "Huel Mexico," which raised about £2000 worth of ore at a far larger expenditure.

Young Henwood began life in 1822 as a clerk in the office of Messrs. Fox and Co., of Perron Wharf, where he continued five years. Happily the nature of his employment enabled him to commence those investigations into the metalliferous deposits of Cornwall and Devon which occupied his undivided attention for nearly 50 years. The first mine he visited underground was the Wheal Herland in Gwinear in 1825, and his first scientific paper was read before the Royal Geological Society of Cornwall in 1826.

[1] Extract from speech by Prof. Huxley, LL.D., F.R.S., President Geol. Soc. 1870. See Quart. Journ. Geol. Soc. 1870, vol. xxvii. p. xxvi.

[2] Extract of a letter from Thomas Davidson, Esq., F.R.S., F.G.S., to whose kindness the Editor is indebted for most of the facts regarding M. Deshayes' life.

For the next 20 years communications from his pen, in every case the result of wide-spread observation and much patient thought, appeared in rapid succession in the pages of this and other scientific societies. The titles of no fewer than 55 separate papers by Mr. Henwood are given in the Catalogue of Scientific Papers published by the Royal Society, and a still longer list appears in the Bibliotheca Cornubiensis.

The whole of the fifth volume of the Transactions of the Geological Society of Cornwall was in 1843 devoted to Mr. Henwood's observations "On the Metalliferous Deposits of Cornwall and Devon" (512 pp. and 125 plates and tables). In 1871 the same Society devoted their eighth volume to the publication of Mr. Henwood's Observations on Foreign and Metalliferous Deposits, a volume even bulkier than its predecessor.

In 1832 Mr. Henwood was selected as Assay Master and Supervisor of Tin in the Duchy of Cornwall, an office which he held until the coinage duties were abolished in 1838, when he retired on a pension. In 1837 the Institution of Civil Engineers awarded him the Telford Medal for his paper on Pumping-engines in Cornish Mines. In 1840 he was elected a Fellow of the Royal Society. In 1843 he went to Brazil to take charge of the Gongo Soco Mines. From Brazil he repaired to India in 1855, to report on the metalliferous deposits of Kumaon and Gurhwal in North-Western India.

He finally retired from active life in 1858, spending his latter years in Penzance. In 1869 he was elected President of the Royal Institution of Cornwall, to which he communicated numerous papers and addresses.

So lately as the present year he was presented with the Murchison Medal by the Council of the Geological Society of London.

He died on the 5th August in his seventy-first year, highly esteemed by all who knew him. Cornishmen may well be proud to claim him as one of their own countrymen.[1]

MISCELLANEOUS.

Mr. William Davies, British Museum.—It will be a source of unfeigned satisfaction to all geologists to learn that Mr. William Davies, who has devoted more than thirty years of his life to the service of the Trustees in the Geological Department of the British Museum, has at length been appointed an Assistant, and will henceforward occupy a recognized position in this scientific Department. It will not be forgotten that Mr. Davies was awarded the first Murchison Medal by the Council of the Geological Society, in 1873, in recognition of his valuable services to Palæontological Science. Those who are acquainted with Fossil Fishes will be able to testify to his great knowledge of this group, which has rendered this part of the National collection especially perfect. His labours in reconstructing the Fossil Mammalia of the Pleistocene Brick-earths of the Thames Valley, and his Catalogue of the fine series of specimens from these beds, collected by Sir Antonio Brady, F.G.S., and recently acquired for the British Museum, attest his extensive practical acquaintance with comparative anatomy. We trust his life may be prolonged and his services continued for many years to come, to his own honour and for the good of science.

[1] Drawn up and abstracted from an elaborate memoir kindly sent by W. Prideaux Courtney, Esq., to the Editor.

Supplement to the Geological Magazine,

SEPTEMBER, 1875.

ACTION OF DENUDING AGENCIES.

ABSTRACT AND CONTENTS OF LECTURE, &c.

March 22, 1875.

By A. Tylor, F.G.S.

PAGES

level to fall below the theoretical curve, a parabola with horizontal axis, Figs. 5 and 5A. Transverse section of Hirwain Valley, Fig. 5B, also in parabolic curve, from my own survey 444, 445

12. Drawing from observation of a stream at a small slope, Fig. 6. Ditto, Fig. 7, of a stream with the same quantity flowing at a steeper slope, showing the difference of stability or stand up of a running stream represented by the difference of depth of water under the same circumstances of slope. Hitherto, slope has often been alone taken into account as the cause of velocity, without calculating the quantity flowing. Explanation of symbols 447, 446
13. Different velocities of streams of different sizes show, that with about twelve times the quantity flowing at the same slope, the velocity was increased about two and a half times, or as the cube root of the increased quantity. Fig. 8... 447
14. Plan of Mississippi, showing the width at twenty-two different towns, the curvilinear river course being represented by straight lines. All navigable rivers decrease in width and increase in depth until they approach the sea. A bar is formed by the opposing current of sand or mud moved along the bottom of the river up a steep gradient (10 feet in a mile in the Mississippi), meeting the sand continually brought up by wind waves from the sea. The opposite forces encounter at the bar; a great quantity of mud and sand overcomes the opposition, and is carried along shore. Colonel Tremenheere found by experiment that the material projected into the ocean by the Indus travelled hundreds of miles along shore, and was found in the harbour of Kurrachee. The long-shore current was often one mile per hour, and continued in the same direction. Figs. 11, 12, and 13 448
15. Plan of Amazon, a river 2,000 miles long, with the acute angle junctions of tributaries at the extremities near watersheds, and the other junctions nearly rectangular. The junctions are rectangular particularly when the main stream is very large, and the junctions in alluvium. Fig. 14... 448
16. Representation of the junction of the Red and other tributary rivers at acute angles with the Mississippi. The great river is deflected from its course by the impact of the Red River, and flows in a line, the resultant of the two forces. A main river is merely the junctions between tributaries. It has no water of its own, and its position in space is the resultant of alernate and opposite forces of side streams throughout its course. Fig. 13 449
17. Representation of the same streams with rectangular junctions, to show how absurd such an arrangement appears. Fig. 14 449
18. Law of alternate headlands and coombs (coombs are steep dry, or wet valleys). These are found along every valley in the world, formed with more or less regularity. The coombs and slopes are often originally excavated by the water issuing from springs along the tops of the unstable and impermeable strata cropping out along the sides of the valleys. The spring water dislodges the face of the stable or permeable strata, and leaves the bared edges of the rock at a steep angle, which edges in the impermeable strata or clays are sloped. Fig. 15 represents a valley in chalk, where the strata are of uniform permeability 450
19. Delta of Danube, showing main stream, dividing first near the rocks of Toultcha, where there are no longer any side streams or hard rocks to keep the river from branching. Fig. 17 451
20. Main river deflected after receiving a branch. Fig. 16 451
21. Velocity in a main stream of two metres per second, shown in diagram

PAGES

from observation, reduced in a branch one-half of the size, to 1·6 metres per second, and again to 1·27 metres per second, in a branch one-quarter the size of the main stream; all the streams at the same slope. This gives an idea of the effect of weight in increasing velocity at the same slope. If the Nile was divided higher than at present, the rise would occur earlier and be higher, as the stream would be slow. The reverse would be the case in the Rhine. If that river was prevented from dividing at its delta it would flow in a swifter course to the sea, and keep a deep mouth open in the sea so as to admit large ships ... 452

22. Mount Tabor, Fig. 19, from a photograph. The outline is compared with a dotted line representing a binomial curve, obtained from the co-efficients of $(a + b)^{10}$. Every symmetrical hill has a convex top and a concave bottom, and is steepest in the middle. This form, so constant in nature, is caused by the watershed being flat, so that little water flows upon the high lands, above ground. Springs escape at the middle heights of the valleys and widen valleys. The action of sub-aerial fluvial and pluvial denudation is not so much to lower watersheds as to widen valleys. Thus, in a great denudation of this kind the maximum height of the mountains and watersheds and the depth of the valleys may be constant.* The valleys could be enormously widened, and the mountain masses thereby emasculated, without the average height of the land been materially lowered. This, of course, supposes that as much material is removed by denudation from any level above the mean as from another below the mean, or rather, that the relative removals balance each other, leaving the mean and maximum heights of the land untouched. For this reason the land can never be all removed below the sea level ... ...

A representation of the binomial curve or curve of denudation, showing how it is set out. Fig. 20. A symmetrical hill curve 452

23. Representation of form of hills in different position, to show that all the surface curves can be represented by binomial curves. The Fishback Hill, Fig. 21, is a very common form, as naturally the watershed is not often exactly intermediate between two lines of drainage. Figs. 21 A, 21 B and 21 C, are sections in different positions of the Fishback Hills 453, 454

24. Hills of Lower Greensand, Fig. 21D, and hills of glacial drift in Sweden, can also be represented by binomial curves. Fig. 21E 454

25. Figs. 23 and 24 represent the case of water passing through fissures in hard rock and washing away the clay below, and causing the formation of Ecclesbourn, which is the type of all valleys. The hard rocks falling into the brooks of any district pave them, and prevent the sands being washed away. This is the cause of Crowborough Beacon standing 900 feet above the sea: without the iron-sand rock, this hill would have been washed away by its brooks. The position of rock and clay at Ecclesbourn, on a very small scale, is that of Niagara on a very large one. The slopes of surface or contour of the land is terraced or shaped into alternate walls and slopes, in consequence of the water escaping over the clays, levelling the wet surfaces of clay, but leaving the rock or sand standing up at a steeper angle than the clay, because less water passes over it and its stability is greater. This is the form of the buttress in architecture; that is, the wall and slope used is the form best adapted to resist atmospheric action—it is the form of

* Mr. Croll has stated without apparently considering the geological evidence, that all land can be reduced to the level of the sea, and he calculates the time by, what I consider, an unsafe method. He has copied my method of 1853, of computing denudation in other respects, without adding any improvement.

ALFRED TYLOR, F.G.S.,

ON THE ACTION AND FORMATION OF RIVERS, LAKES, AND STREAMS, WITH REMARKS ON DENUDATION AND THE CAUSES OF THE GREAT CHANGES OF CLIMATE WHICH OCCURRED JUST PRIOR TO THE HISTORICAL PERIOD.*

(*March 22nd*, 1875.)

MY lecture will relate to the consequence of the flow of water and ice, that is, to the motion of rivers and streams and of glaciers, and their effect in producing erosion or denudation, as it is called, of the surface of the earth.

I hope to prove, by diagrams, the effect of the excessive rainfall and snowfall in former times, when the earth received its sculpture or superficial configuration. The extent of the ancient rivers and glaciers is shown by the dimensions and shape of the present hills, lakes, and valleys. I believe, and I hope to convince you, that the present forms and shapes of the surfaces of the earth are due to events which happened at or about the time of the arrival of man, when atmospheric conditions were extremely different to those at present. These views I have held for twenty years, and they are, of course, entirely contrary to the views of the late Sir C. Lyell, who never admitted a pluvial period.†

Then I do not think, in the present theory of regelation of ice of Faraday (in 1850) and Tyndall (in 1857), that these writers have taken into account all the circumstances of the case.

(2) The formation of great and deep lakes is a great difficulty; it has been asserted by Professor Ramsay and others that some of the Swiss lakes were formed by glaciers, but the present accepted theory of the motion of ice does not, I think, give a possible explanation of the formation of large lakes, thirty or forty miles long and 1,200 feet deep. Such a work involves the carrying out of a vast quantity of material from the lake bed, against the action of gravity. (See Fig. 1.)

I hope to show, by taking account of what I think has been omitted or neglected—referring to Fig. 1, which I will now describe—that an upward and forward movement would occur in the lake-glacier, due to the greater weight at the upper end. Then I think one consideration has been omitted, viz. the effect of the friction of ice, during motion, in producing heat, by which a large quantity of water is produced. Fig. 1 is a glacier one mile thick, occupying and filling a lake 1,200 ft. deep, and excavating it at the rate of half-an-inch over the whole surface in one year in the glacial period.

I think De Charpentier (in his "Essai sur les Glaciers," 1841) was right in supposing that water, freezing in the glacier itself, and expanding, gave motion to glaciers, although that is disputed. He worked with the great Agassiz, who discovered the glacial period in 1837. Playfair first discovered the geological importance of glaciers in 1802.

The movement of a lake-glacier, I believe, is assisted by three different forces impelling it forward, and retarded by two resisting forces, as shown in my diagram.

The impelling forces are, 1. Gravity, measured by the slope of top surface.

2. Pressure from behind, due to the heavy weight of glacier behind acting on the ice which is treading in water, and causing the front end of the glacier to rise, just as the weight of the Victoria Tower in Westminster caused the bed of the Thames to rise; or as a weight applied in the formation of a railway

* [This Lecture was illustrated by some new experiments on ice, and by reference to new experiments made by the Lecturer to prove the amount of ice thawed by friction of ice upon ice, which is an important and new element in explaining glacial motion.]

†A. Tylor, Quart. Journ. Geol. Soc., vol. xxv., pages 9 and 63, 1869; vol. xxiv., page 105, 1868.

embankment on a morass, caused upward motion of the peat and bog often as far as the marsh extends.

3. The effect of the congelation of the water produced by the friction of ice upon ice expanding the lower part of the glacier, and producing the forward motion. This third cause was De Charpentier's principal source of motion.

The two resisting forces are the friction against the bottom and the resistance of the mass, and the having to lift the bottom of the glacier against gravity.

The chemical explanation has yet to be given, I think that meets the case entirely.

(3) The effect of evaporating ice and water even at low temperature in producing increased cold has not been alluded to, nor the absorption of water by the

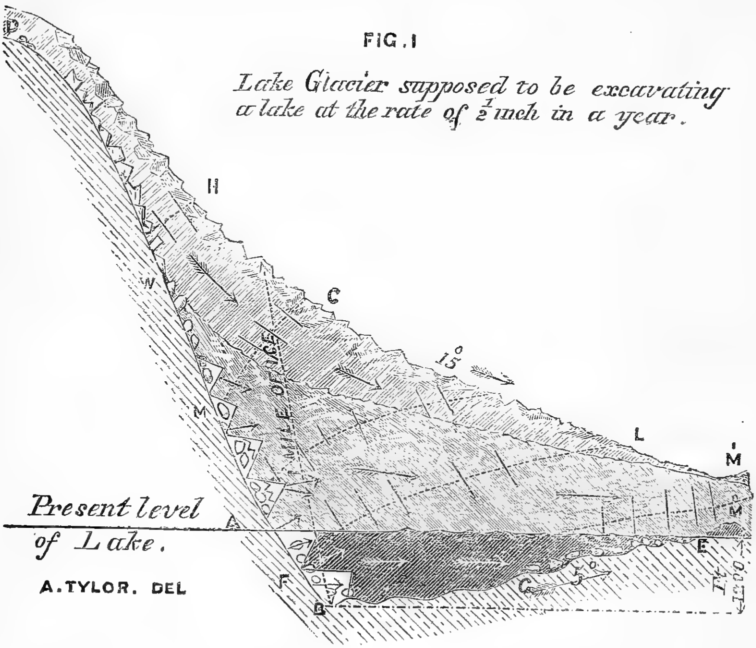


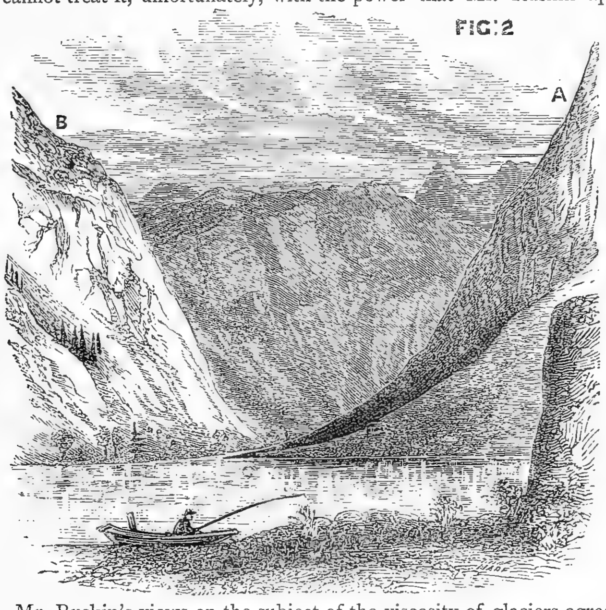
FIG. I

Lake Glacier supposed to be excavating a lake at the rate of ½ inch in a year.

pores of ice. This is also an action, I believe, equivalent to evaporation, and causes great abstraction of heat from the surrounding ice, and great cold at the surfaces, where absorption occurs. And this cold converts a certain quantity of water into ice, joining surfaces of ice together at 32 degrees. That the now well-known theory of regelation is a correct one I do not doubt. That heat is produced by the friction of ice upon ice was proved by Sir H. Davy. Thawing has been said to proceed at lower temperatures under pressure by Professor J. Thomson, but little observation was adduced in proof of this in the Papers published in 1857 and 1858 in the Proc. Roy. Soc. Edin. It is quite possible that ice may not freeze at a temperature below 32 degrees under pressure; as we know water can be cooled much below 32 degress, if perfectly still. When motion ensued, the production of heat by the friction of the particles would warm the water, and raise the temperature at the moment to 32 degrees. The mean temperature at the surface, where the old ice is in contact with the new ice forming, may be 32 degrees. In the ordinary regelation experiment the wet surfaces of ice are put close together, and a portion of the water is evaporated into the pores of the ice, and heat is abstracted, so that the remaining quantity of water is frozen uniting the pieces of ice together. Regelation does not occur when there is a thick film or sheet of water between the two surfaces of ice, unless the ice is much below 32 degrees, or there is pressure producing currents and evaporation. Ice, although not exactly a colloid, may have cells which admit of exosmosis and endosmosis in the gaps between the internal crystalline surfaces.* There may be one-tenth of the whole bulk of the ice occupied by such cavities. This could be proved by freezing an hydraulic press of excessive strength containing a small film of water and an observing tube When a mass of water was frozen in a mortar, a shot of 3 lb. weight was ejected 415 feet.†[2] No pressure gauge was introduced in this Canadian experiment.

Mr. Ruskin, on the 11th of this month, explained his views of glacier action, and interested you very much. The subject to-night is almost a parallel one, but I cannot treat it, unfortunately, with the power that Mr. Ruskin applied

FIG: 2



to it. Mr. Ruskin's views on the subject of the viscosity of glaciers agree with those of Prof. James Forbes, and are different to those I shall state to-night.

(4) Glaciers are but frozen rivers, and they obey the same great laws of motion that rivers follow, although the advance forward of a large river is as much in a second as that of a large glacier in a week. No one has constructed a large glacier artificially to experiment upon; while Darcy and Bazin experimented on the flow of water in many kinds of channel. See their "Recherches Hydrauliques," Paris, 1866.

* On page 40, Note 1, the action of ice almost resembling a colloid body during the act of regelation is described. † Ganot's Physics, page 261.

Ice experiments could be well tried on a large scale in Switzerland, Norway, Russia, or in Canada, where the temperature of the air is low.

By your permission I would attempt a new explanation, to show a possible mode in which lakes high above the sea level are formed by the action of ice; that is, by glacial action. The motion is due to *vis a tergo*, like the slope movement of marshy ground when loaded by an embankment.

(5) The outlets of all such lakes in mountainous districts are high above the lowest part of the bottom of the lakes themselves. Deep lakes as Fig. 2 are always embosomed *in* the mountains by whose glaciers they were formed. Deep lakes are purely the mechanical consequence of high and steep mountains from the poles to the equator. Given the position and depth of the lakes, it is often possible to predict the position of the mountains.

I have shown, in Fig. 1, a lake which you may suppose to be that of Zurich or Lucerne. The outlet, or outfall, of this lake is in hard rock, and it is evident that the whole of the material which formerly occupied the lake must have been, at some time or other, excavated, or dug out, as it is not possible to suppose any other hypothesis.

I hope to show how glaciers—that is, ice holding boulders or rocky blocks firmly in its grasp, dragging along the bottom—can perform this difficult operation.

As glaciers have a considerable motion, although a slow one, these rocks shown in the diagram are like tools or shears, which plough up the surface of the earth and push the loosened material up a slope into the outfall.

It is possible to explain by this drawing how a glacier, having hard boulders firmly embedded in the bottom, can drag these along the bottom and cut out the rock and push it up the lake-bottom against gravity, over the outfall, from which it would be removed in the usual way, if the glacier can move forward from top to bottom. In the glacial period the mean temperature of the ice must be assumed at ten or twenty degrees below freezing, although now near the freezing point in modern glaciers.

There is one condition necessary to be admitted, and that accords with observation—viz. that the bottom of the glaciers must be wet, and at 32° Fahr., or about that temperature. If colder, the ice would freeze to the bottom and no motion would ensue, and if warmer the ice holding the boulders would be thawed and there would be no erosion taking place.

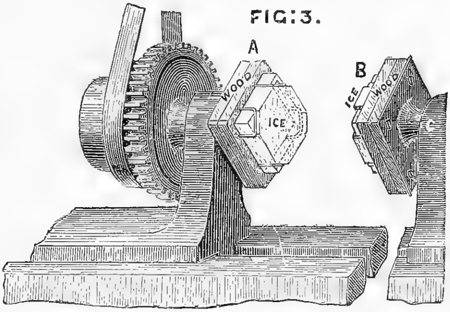
All observations show that all modern glaciers move in constrained, and not in free motion, and more in summer than in winter, and that there is a thin wet or watery surface between the glacier bottom and the ground of the valley it moves in. There are greater deviations in glaciers from their mean motion than in rivers from their mean motion, but still glaciers move forward in a mass, and the front ice is not overtaken by the back ice.

Now the fact of the greater motion in the day than in the night, and in summer than in winter, is an indication that the greater the quantity of water present in the glacier the greater is the motion. The action of a quantity of water at the bottom of the lake, and in the fissures of the glacier, would tend to float the lake glacier to some small extent, or at least to place it in the unstable condition of marshy ground. We know that when a railway embankment or a large building is erected on a marsh, elevation of the surface of the marsh takes place at a long distance from the point where the weight is applied.

In order to render the motion of the lake glacier possible, such as that represented Fig. 1, we want a certain quantity of water constantly produced, and that part should soon freeze, so as not to increase the stock of water. I think the congelation-dilatation theory of De Charpentier, with some modifications, helps to explain lake glaciers. Although Sir H. Davy pointed out that ice rubbed against ice produced heat, yet this has not been taken into account in any of the theories of glacier motion, and I mention it now for the first time in a public lecture, that there is a possible source of heat to produce the water found in all glaciers, arising from the friction of the ice in the glacier itself; and that the act of regelation or freezing, accompanies exosmosis from the water into the cells of the ice, the evaporation of part of the water abstracts heat and causes the rest of the water to freeze.

(6) I do not understand why this action has not been previously suggested, for by pressing four pounds of ice against, or by revolving two blocks of ice such as these, 8 inches in diameter, for an hour, 1½ pounds of water can be produced, at a temperature, much above freezing (Fig. 3). The ice was revolved in a metallic chamber, commencing at 32° Fahr., but the temperature soon arrived at 40°, on account of the heat transmitted from the ice to the air touching warm air entering the case, and from the water being warmed by friction between the two surfaces it lubricates. I found the friction of ice upon ice to be near that of oak upon oak, well lubricated. This experiment does not appear to have been previously tried, and should be repeated under varying conditions to arrive at the actual co-efficient of friction, and should be tried in the manner adopted by General Morin and others, and in a cold climate. Velocity of movement does not increase friction. Friction is dependent upon mass, distance moved, and nature of surface. The co-efficient of ice is between 0·1 and 0·2.

FIG:3.



The source of water at the bottom of a glacier is, I think, due to the heat generated by friction of ice upon ice, by the movement of the glacier to a great extent. The source of the subsequent congelation, I thiuk, is the evaporation of this water, and its reception by frozen ice. Hitherto the accepted source of the glacial water is only supposed to be that which may be obtained from the snow or ice on the surface of the glacier, melted by the sun's rays, and falling through fissures to the bottom. Ice will evaporate at any temperature, forming vapour, which would pass into the fissures or fractures made by the ice breaking contact.

I can only conveniently show that ice rubbed against ice rapidly, produces water freely, in such a case as my experiment. This experiment is somewhat different from the actual case of a glacier. Then regelation only occurs at 32° to the water adherent by molecular attraction to the surfaces of the ice. When a lump of ice is surrounded by a mass of water at 32°, it thaws. It must, however, be remembered that, there is a certain amount of elasticity in ice when a great many yards of ice are set in motion by varying pressures of ice in the rear, and by gravity, when the tension or torsion arrives at a certain limit, fracture ensues; the divided surfaces rub with great force against each other, and the motion of disruption, although not instantaneous, may be excessively rapid.

Heat is produced by the friction of any solid against any other solid, and ice is no exception. This heat converts ice into water. No doubt part is immediately taken up for regelation, but sufficient falls to the bottom through the fissures to lubricate the glacier, and when frozen to move the ice forward.

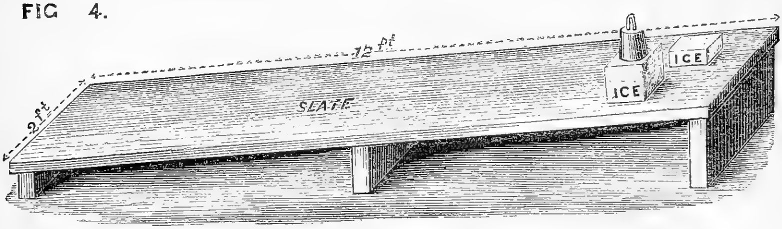
Heat is also produced by the action of the ice moving boulders on the earth.[3] If the mean depth of the lake of Zurich (Fig. 1) could be increased half an inch in a year, that lake might have been comfortably excavated in 15,000 years, which is certainly less than the glacial period.

(7) I propose to attempt first to prove to you a new law ascertained by experiment on motion of bodies down inclines in constrained motion, and thus to show you how much weight affects and increases motion. This law is most important to my argument. Then I propose to contrast the new experiment on constrained motion with the old experiment of free motion, where bodies fall at one velocity irrespective of their weights, that is *in vacuo*, without touching any substance of any kind in their fall. This is shown by reversing a glass vessel exhausted of air, and holding a light and a heavy body.

Bodies of the same size and of different weights also roll at nearly the same velocity down an incline, as we see when the surfaces in contact are so small (as in spheres) that the motion approaches a fall in air, or free motion.

[These experiments were then successfully performed in the lecture-room, by my son, J. J. Tylor, on a slab (Fig. 4.) Two pieces of ice of the same size and weight, slid at the same velocity. But when one was loaded to eight times the weight, it travelled twice as fast.]

FIG 4.



I have before me an inclined plane of slate twelve feet long, two feet wide, down which pieces of ice of different weight will slide at different velocities, while spheres of the same size but of different weights have much the same speed.

This new law—of weight increasing the velocity of bodies in constrained motion in a definite proportion or ratio—has an important application upon the subject of my lecture, because it bears on the infinitely greater action of rivers and springs in former times, for the following reason : I find, by calculation, that with twenty times as much rain, rivers may have swollen for a short time to 400 times their present volume, and then have eight times their present velocity, for the increase of velocity is as the cube root of the increase of weight of water flowing. The large currents arising from a very small slope in the surface of the ocean, are due to this law.[4] Ocean water would move with one thousandth part of the slope of a small stream, if the ocean stream is one thousand million times the volume of the small stream. Ancient glaciers travelled many times faster than the present ones down the same slopes, and reached much lower levels in consequence. Modern glaciers are only one-third of a degree below freezing, but older glaciers were probably very cold.

Certain theoretical consideration as to the effect of pressure in modifying the point of freezing have been accepted without sufficient experiments having been made ; and the present accepted glacial theory has been thus constructed, partly upon observation, and partly upon theory not confirmed by experiment, which is unfortunate. There is no *à priori* reasoning possible in physical science. No theory has ever yet been established, except based on careful experiment, in any branch of science. I therefore submit even my imperfect experiments as much better than mere theoretical views.

The results of observation have, no doubt, corrected many erroneous views about the flow of water; and when similar labours are expended upon ice, we shall obtain more accurate knowledge than at present.

(8) There are many separate works on the theory of the action of glaciers, which are physical agencies of far less importance than rivers. The modern glacier theory turns on the experiment of regelation, that is of pieces of ice at 32 degrees joining together or freezing. This action I do not think has been sufficiently limited or investigated. Snow evaporates at very low temperatures, and this must be a source by which heat is consumed, and the surrounding snow cooled. Regelation only occurs when the quantity of water to be frozen is so small that the part that evaporates into the pores of the ice, cools down the rest of the water below freezing point by the heat abstracted in evaporating the first portion of the water. Regelation does not occur when two dry surfaces of ice are rubbed together, because heat is then produced by friction.

The bubbles or cavities in ice, if they still contain air, all appear to contain air at a low pressure, or in an attenuated form. The instant two dry surfaces of ice are rubbed together, part passes into water by the friction producing heat.

RIVERS.

(9) There is no special and exhaustive book written on rivers, but there are many reports of engineers on different rivers, such as Humphreys and Abbott on the Mississippi, Sir C. Hartley on the Mouths of the Danube, Revy on the La Plata, and chapters about rivers are to be found, in books of physical geography and general mechanics. Sir Proby Cauttley has published a most valuable work on the Ganges Canal.

The absence of a special book on rivers describing the physical geography of their basins is surprising, considering the importance of the subject, scientifically and commercially, and also in an agricultural and sanitary point of view.

In the Rhine, the hard rocks near Bingen have raised the flood level 14 ft.

I shall now try to prove to you that rivers cut out their beds and valleys to such a slope as is shown in Fig. 5, so as to attain such a curve and cross section as would give uniform velocity to the stream. Also that water generally travels down stream, in a navigable river, every day at one rate, not overtaking the water before it, and that glaciers have, from the same cause, the same tendency to uniform mean motion. Floods and avalanches are both exceptional occurrences. In Figs. 6 and 7 I give a diagram explaining uniform mean motion. I believe that a river is a machine for inducing uniform motion in the water flowing in it. This is its real function, but it has escaped notice. So little was known by the public about the proper use and function of rivers, that it was supposed they were only intended for navigation, and for use as drains, and not worthy of a book to themselves. Their strncture is, however, I think, one of the most beautiful adaptations of simple mechanical means to perform a most complicated office in nature.

It was not until Mr. Smee, one of the Managers of this Institution, stopped the Croydon Board of Health from turning a sewer into the River Wandle that it was ascertained that the common law of England was sufficient to prevent persons throwing what substances they pleased into rivers.

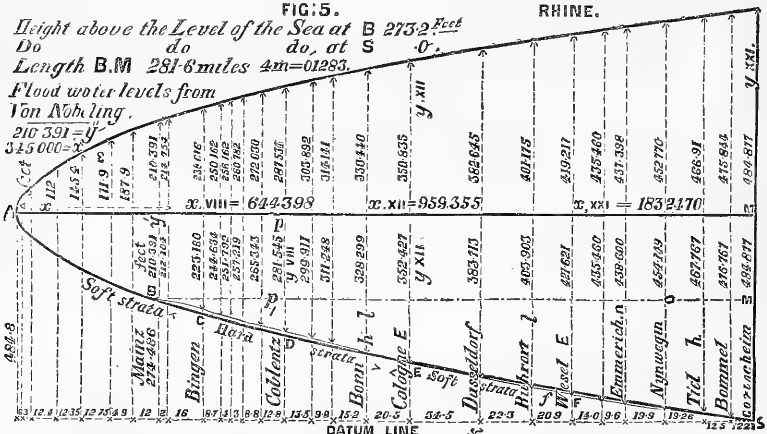
The mechanism of rivers has not, I think, yet been understood, for everyone has appeared to have the full expectation that any river would dispose of anything that was thrown into it without further care.

I am not going to attempt to-night anything more than to establish some general propositions about the action and the motion of water in rivers, and of ice in glaciers, and the causes it depends upon; and to show how the surface of the earth is eroded, and how enormously increase of quantity of water or ice increased denudation or erosion of the land.

I can prove that motion is in proportion to slope of channel and the quantity of water flowing, jointly, by the result of experiment. My diagrams, also, are correct representations of the forms and contours of cliffs and valleys actually caused by the action of rain and spring-water, rendering beds of sand and rock unstable on a surface bed of clay. The actual slip that has occurred is the measure of the instability, and is dependent upon the angle, the weight, and the lubrication by water of the surfaces sliding on each other.

(11) For large rivers I take the Rhine (Fig. 5); but as the most remarkable rivers are in Asia, Africa, and America, I ought to allude to those countries,

FIG:5. RHINE.



Flood level of Rhine compared with Parabola with horizontal axis of the formula $y^2 = 4\,m\,x$ B. TYLOR. DEL.

FIG. 5*. RHINE

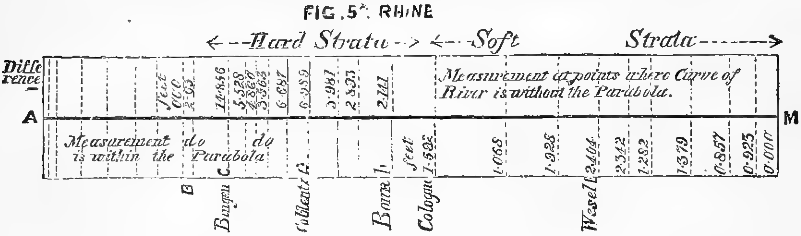


Fig. 5. The Rhine shows that rivers flow, where navigable, in a curved basin. The hard rock raises the water level, the soft lowers it. Fig. 5 is a type of all other navigable rivers, 4 m = 0·1235 feet in the Rhine, and 0·06179 feet in the Mississippi. All rivers approaching to Fig. 5 where navigable.

One great difficulty of my subject is, no doubt, the existence of large lakes such as we see in Snowdonia, and still larger in Switzerland. Now I believe that rivers could at no time form lakes, for the action and function of our present rivers is to fill up all hollows and produce a channel of such a form and slope that the water approaches to uniform motion from adjusting the

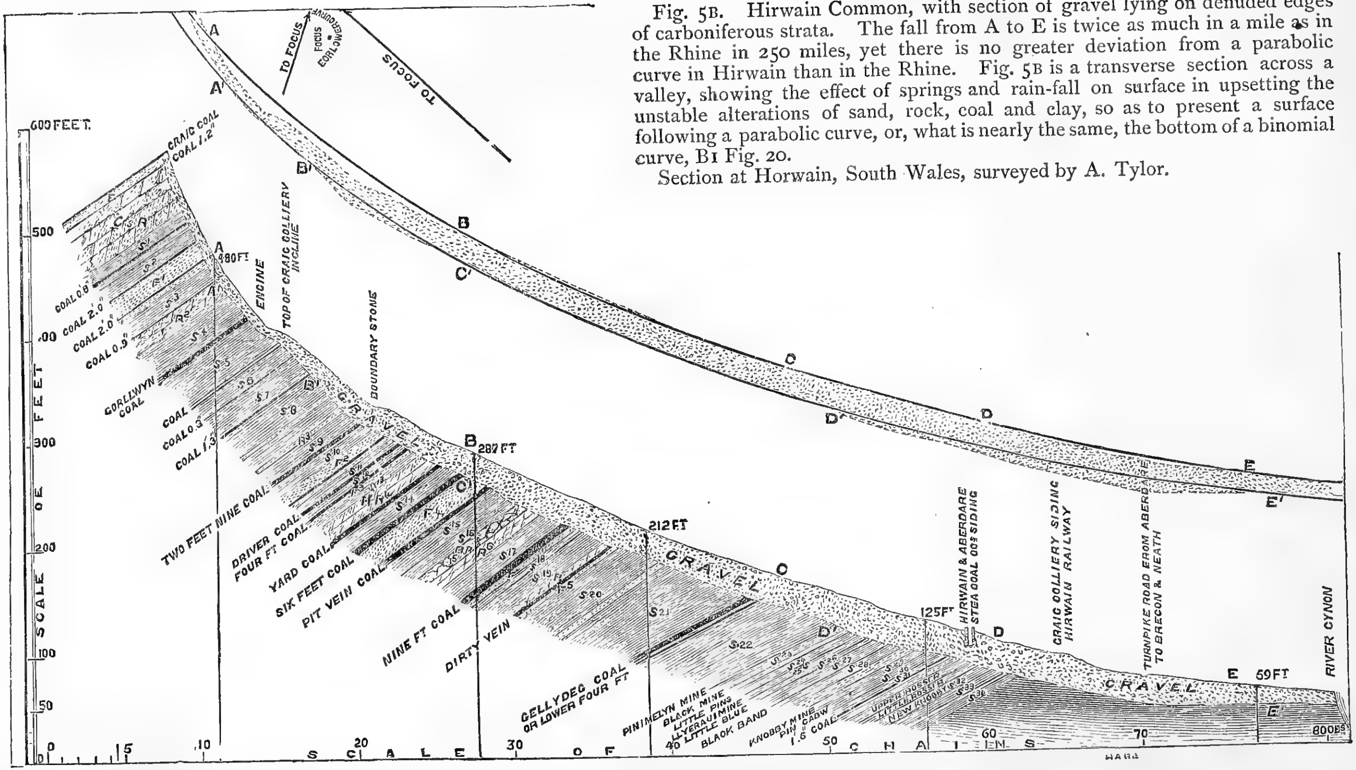


Fig. 5B. Hirwain Common, with section of gravel lying on denuded edges of carboniferous strata. The fall from A to E is twice as much in a mile as in the Rhine in 250 miles, yet there is no greater deviation from a parabolic curve in Hirwain than in the Rhine. Fig. 5B is a transverse section across a valley, showing the effect of springs and rain-fall on surface in upsetting the unstable alterations of sand, rock, coal and clay, so as to present a surface following a parabolic curve, or, what is nearly the same, the bottom of a binomial curve, B1 Fig. 20.

Section at Horwain, South Wales, surveyed by A. Tylor.

slope. The Scotch Lochs have been attributed in 1862 to erosion, or excavation by glacial action, by Mr. J. F. Jamieson, the eminent Scotch geologist, who observed that boulders had been pushed by ice uphill 700 feet (Quart. Jour. Geol. Soc., vol. xviii., page 178). Professor Ramsay, page 203 *op. cit.*, takes the same view of the glacial origin of the Scotch Lochs.

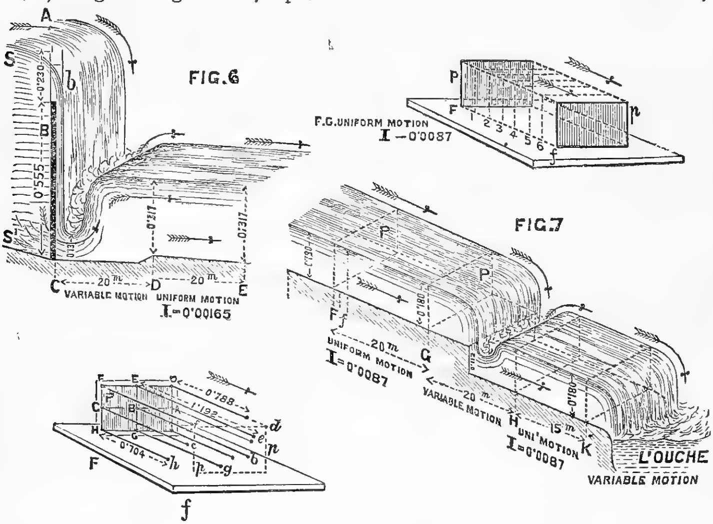
An approach to uniform motion occurs in all rivers except when there are floods.

Fig. 5 represents the slope of the surface of a large river, corresponding closely with the theoretical curve, a parabola of the form drawn.

Fig. 5A gives the deviation from the true curve, in feet, at 22 towns.

The bed of the river acquires such a cross section that water may flow in uniform motion from one end of the river without the back water overtaking the front water in the river. Fig. 5B represents a transverse section of a valley.

(12) Diagrams Figs. 6 and 7 represent a stream of water in an artificial channel,



at one point in variable motion, and at the other in uniform motion. I is the slope per metre.

In the experiments, the water ran about forty yards before it obtained uniform motion.

The depth of the stream represents what may be termed the stand up, or stability of the stream for that particular quantity flowing, and the particular slope and material of channel. A and a represent cross sections; V and v, velocities; O and q discharges; I and i slopes of the different channels compared. The velocity increases as the cube root of the increase of quantity at the same slope, ane the velocity increases as the cube of the increased slope when the quantity flowing is the same.

(13) Fig. 8 shows the different effect of depth and velocity for a certain small quantity flowing at the same slope as a larger quantity. The velocity in D channel when twelve times the quantity is flowing of that in B, is 2·3 times that in B. That is, the change is from 0·502 to 1·278, and 2·3 is the cube root of 12·167.

Fig. 9. The velocity from A to E is nearly the same; that is, notwithstanding the difference of slope, the velocity is nearly uniform, owing to increase of quantity balancing decrease of slope.

Q represents discharge per second in cubic metres. Fig. 6 to 9 and 18.

A—Cross sections in square metres.

V—Mean velocity in linear metres.

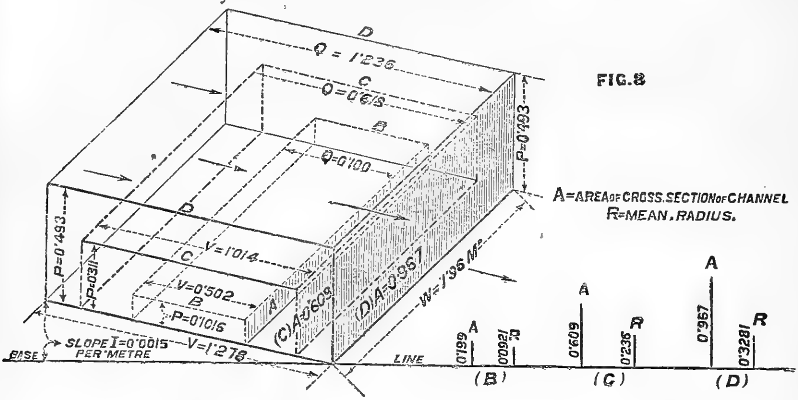


FIG. 8

(10) The equation to uniform motion, that is when velocity is equal and $v = V$ is (4) $\frac{I}{i} = \frac{1}{2}\left(\frac{A}{a} + \frac{q}{Q}\right)$ See explanation at end of this pamphlet (page 36), and Phil. Mag., 1874, page 205.

Fig. 9 is constructed by taking a number of channels, where observers had found by experiments the exact depth and cross section of the stream, in uniform motion when the velocity and depth were known. In fact if such channels were

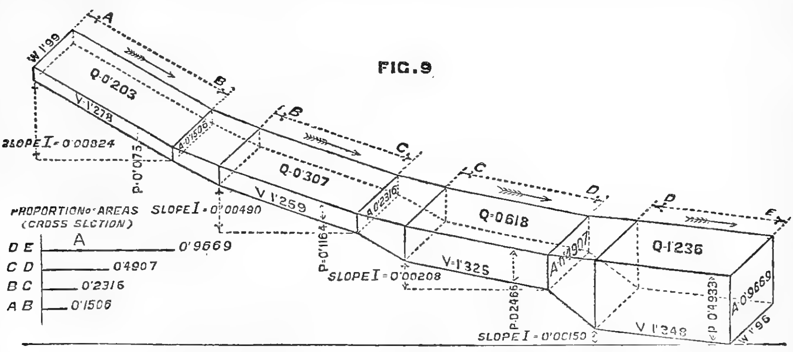


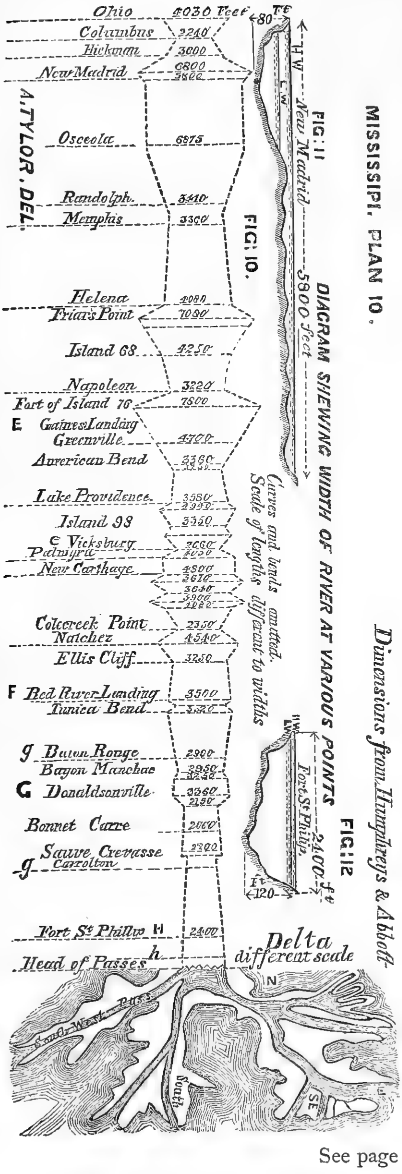
FIG. 9

constructed at different slopes, and the quantity of water flowing at each channel was regulated according to each case as described in the diagram, the water would arrive at nearly the same uniform motion in each case.*

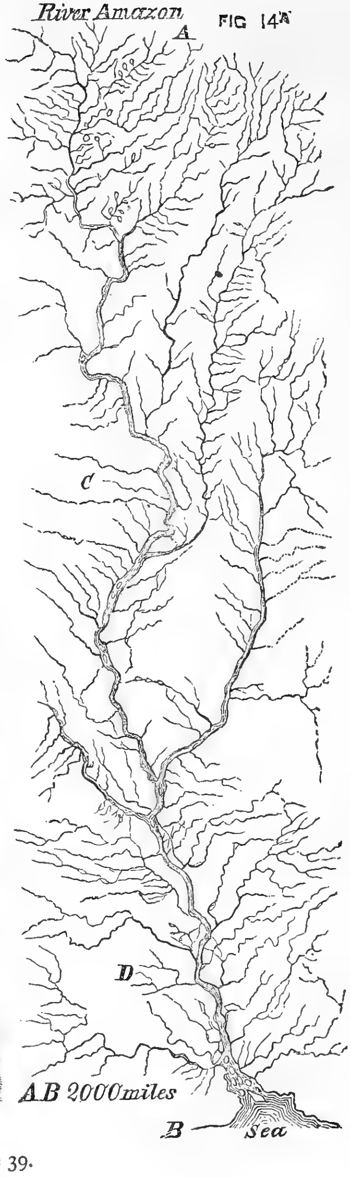
This is what happens on a real navigable river. As each tributary comes in

* See note to page 39 referring to Fig. 9, uniform motion of navigable rivers.

14.



15



See page 39.

the slope of the main stream diminishes as the water increases (see page 467).* It will be seen that a near approach to uniform motion is obtained. There is an exception when very hard rock is met with, and backwaters. A tributary containing one-hundredth part of the water, but flowing at one hundred times the slope, would enter the main river at the exact speed of the main river.

I found, except when the shallows impeded the ships by reflecting waves back from the bottom of the river, in the Rhine, the quantity of coal used, and the speed attained by steamers, was uniform from near the mouth of the Rhine to Mainz. (Fig. 5.)

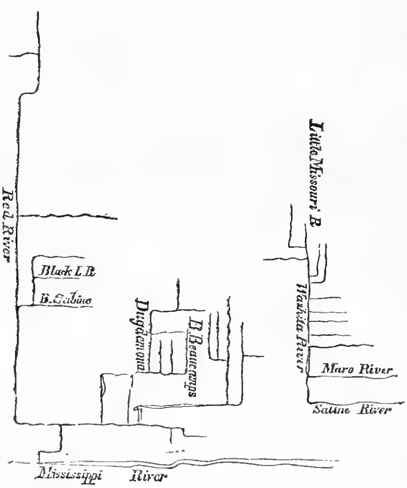
Fig. 10 shows the great width of a large river 1,000 miles from the sea, and decrease in width as it approaches the sea. This is the general case with large navigable rivers. Directly the bar is passed a ship can sail hundreds of miles in deep water.

Fig. 11 is a cross section, a thousand miles from the sea:

§ 16. FIG: 13.

Actual junctions of Red River and other tributaries with Mississippi at acute angles.

§ 17. FIG: 14.



The same river as in Fig 13 joined at right angles to shew the impossibility of the arrangement.

Fig. 12 is a cross section near the Delta, proving the above law.

Fig. 13 shows the natural junction of the tributaries of the Mississippi coming in at an acute angle.

Fig. 14 shows the imaginary junctions, supposing that in this river, the branches could unite at rectangular junctions. How absurd this appears. These drawings, made in 1871, are applicable to refute the theory advanced by Professor Ramsay, of the Rhine having reversed its course. The angles of tributary valleys are all such as would be produced by a river flowing in the present direction in the Rhine valley.

* See Note 4, page 472.

Fig. 14A represents the Amazon. The junctions in the mountains are at acute angles, but near the mouth almost at right angles, as in all rivers.

(18) Fig. 15 is a drawing of the alternate headlands and coombes observed on the sides of every valley in the world.

FIG. 15

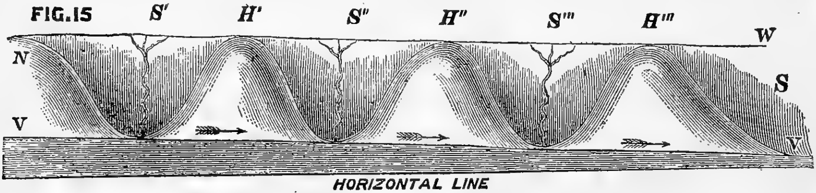


Fig. 17 gives a plan of the Delta of the Danube, from the works of Sir C. Hartley. I give it merely to show that the cause of a river forming a delta is, that there is no longer in its course any tributary streams to keep the river in one channel by equal and opposite actions, from the brooks and rivers falling into the valley from alternate sides. This is the case in all large rivers having deltas.

Fig. 16. The line F C is the exact resultant of the unequal forces coming from F F and C A.

Fig. 16 shows the effect of a tributary in changing the line of the main stream, which is the exact resultant of the forces if between the two streams joining, allowing for the respective differences of slope and quantity flowing in each tributary. If the tributary joined at 45° and was $\frac{1}{45}$ the volume of the main river, it would deflect the main stream one degree.

Thus valleys are deflected from their direction, at the junction of tributary valleys. If the area drained by a great river is of symmetrical form, the river will occupy the medial line, and be the resultant of the alternate and opposite forces of tributaries coming in on the opposite sides of the valley the main stream occupies.

FIG. 18

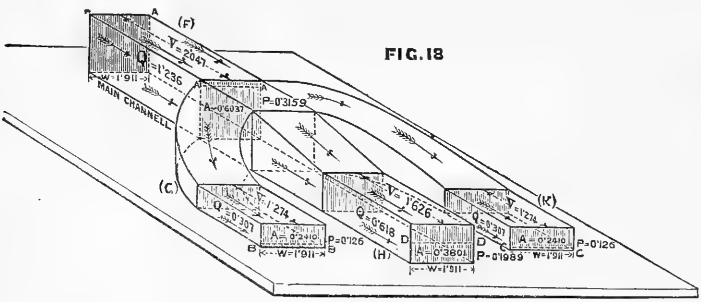


Fig. 18 is a case giving the effect on velocity in relation to different quantities flowing, by diverting a large channel into three channels, one twice as large as the other two. If the Nile was artificially divided higher up than at present, the current in the three streams would be much slower than at present, and the rise of river earlier and higher. If the Rhine was prevented from dividing, it would flow out to sea in a good stream, so as to keep a passage open for large ships.

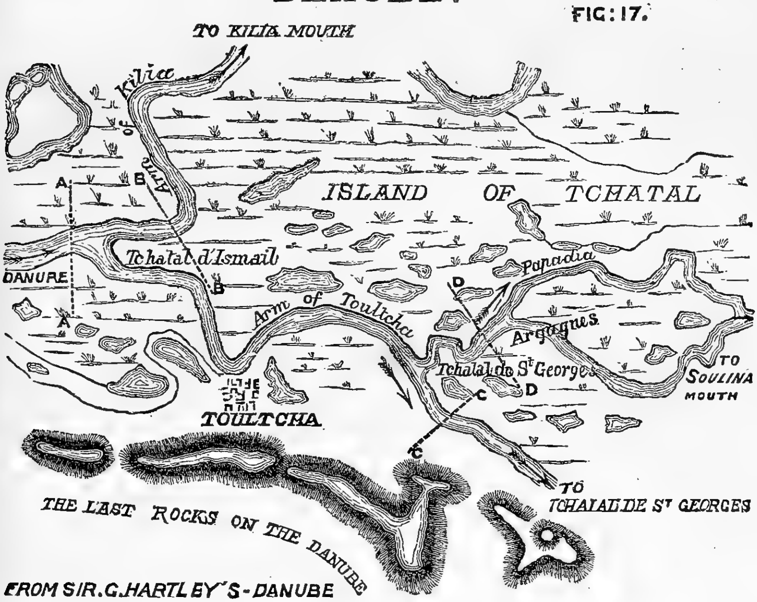
From what has been seen in Fig. 8 and in other diagrams, although all these streams are at the same slopes, the mean velocity of the single stream before it divides will be greater than either of the others; and the mean velocity of the larger stream of the three will be greater than the two small ones, although

(19)

DIAGRAM SHOWING THAT THE RIVER DIVIDES AFTER PASSING LAST HIGH LAND ON ONE SIDE OF THE VALLEY.

DANUBE.

FIG: 17.

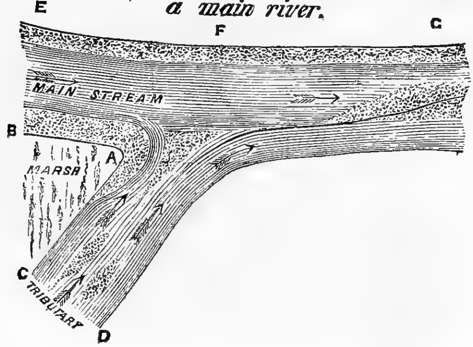


FROM SIR.C.HARTLEY'S-DANUBE

(20)

FIG 16.

Angular junction of a side stream with a main river.



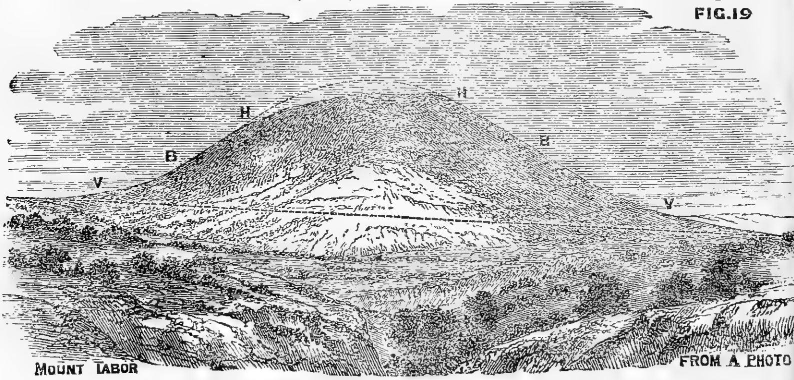
all are at the same slope: this is owing to the effect that quantity flowing has upon velocity. Thus the velocity in F is 2·047; in H, 1·628; and in G and K, 1·274.

(21) The channels in Fig. 18 are taken from four observed cases of water in uniform motion; and if a channel was divided, as shown in Fig. 18, the above would be the real velocity.

These new laws, already spoken of, might be applied in practice to such a river as the Nile to produce longer irrigation.

Fig. 18. The mean velocity would be much reduced by dividing the river much higher than the present Delta. If three or more artificial channels were made, the streams would be much deeper and slower, although at the same slope as

FIG. 19



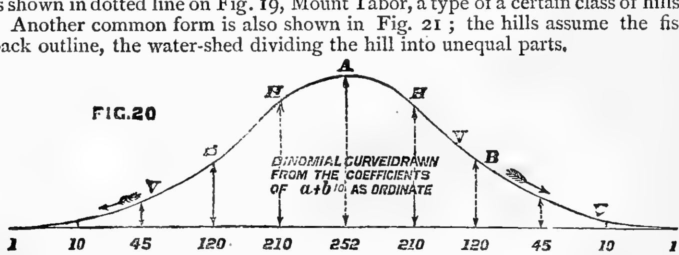
MOUNT TABOR FROM A PHOTO

at present; and they would, and might, give an irrigation to the desert of Egypt, which would be of immense agricultural value, by causing an earlier and larger overflow of the Nile. The opposite is also true, that rivers joined at the same slope traverse with greater velocity. If the rivers of the Rhine Delta were joined so as to have one mouth, the Rhine would have a deep navigable mouth, and the stream, by its velocity, would always keep 22 feet of water at the bar.

Fig. 20 is a diagram, the outline of which is a true binomial curve. This curve is shown in dotted line on Fig. 19, Mount Tabor, a type of a certain class of hills.*

Another common form is also shown in Fig. 21; the hills assume the fish-back outline, the water-shed dividing the hill into unequal parts.

FIG. 20



The letters W W indicate the water-sheds. Fig. 21A and 21B are the binomial curves set out in a proper manner from the coefficients of $(a+b)^{10}$. The water-shed being out of the centre in Fig. 21 produces a different form to Fig. 19.

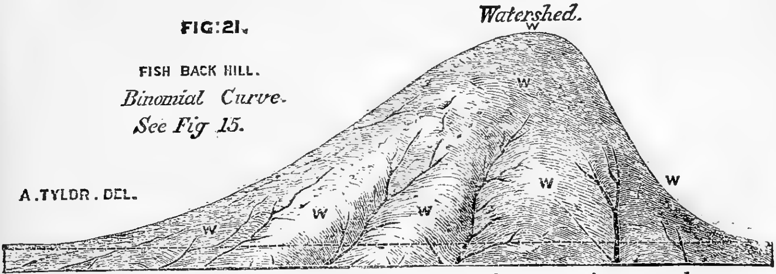
Fig. 29, p. 460, Black Gang Chine, represents the effect of erosion and denu-

* The best general definition of a hill is that it is the convex portion of ground (*B A B*) lying above the concave part, or valley (*B V I*). The springs burst out most at *B* and *B*, and make that part of the curve the steepest (see Fig. 20). Although the surface of Fig. 19 appears smooth, it is no doubt a succession of small walls and slopes.

dation on a soft series of sand and clay-beds. Water enters by fissures and cracks along the upper surface of the alternate beds of clay and sand, when it reaches the air, where there is little or no weight of rock to keep the sand and clay from sliding, motion ensues, and the outer surface of rock or sand is dislodged. With eight times the quantity of water flowing along these unstable surfaces the destructive effect might be as the cubes, or nearly 500 times as much as at present.

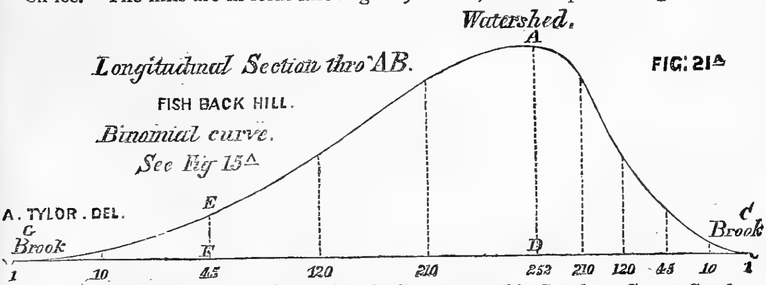
(22) I have shown what I believe to be the typical form of a hill, drawn from a photograph of Mount Tabor, Fig. 19. This hill has, I believe, a base of seven miles, and the surface has been eroded into the binomial curve, which is, I consider, the form of greatest stability. It is the form which gives the nearest possible approach to uniform motion of water on its surface.

May Hill, seen from Gloucester, is a good example of this form, which is common to the hardest and softest rocks, and even to clay and sand.



Hills of drift have been drawn by Jamieson and others not quite so regular or uniform as those in Sweden.

The drift hills, 40 feet high, on Hirwain Common, 200 feet above the river and two miles from Aberdare on the Neath-road, contain blocks of millstone grit many tons' weight, and rolled pieces of old red sandstone transported on ice. The hills are in form like Figs. 19 and 21, but not quite so regular.



(23) If hills of glacial drift on Hirwain Common and in Sweden, Green Sand hills near Leighton Buzzard, and Sandown in the Isle of Wight, and in fact in all formations and countries, assume this form, it is because the formation of sloping surfaces in all hills and valleys is really the same natural process to be observed in an exaggerated form in most waterfalls. See Fig. 23, p. 456. The law for waterfalls is, twenty-seven times the water would produce as much destruction in a day as now occurs in a year. Water filling the brook at Ecclesbourn, passing through the fissures and carrying away the soft clay or shale (which in most waterfalls underlies massive jointed rocks) produces instability; and as soon as the surface of the clay is washed away, the rock is undermined and falls down.

Now these pieces of rock remain in the stream, and protect the underlying beds. With torrents flowing, protecting rocks would be carried down, and valleys excavated with the greatest rapidity. Our hills were shaped by the same process.

Fig. 21E represents a hill of glacial drift drawn by Erdmann. It is evident that the disposition of the internal strata does not materially affect the contour. From page 57 Formations de la Suède.

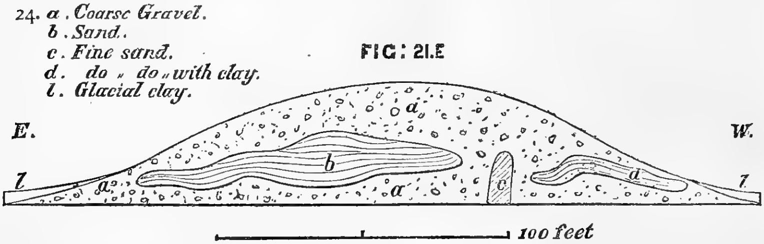


Fig. 21D. Sketch of outline of sandhills, near Leighton Buzzard, Beds.

Crowborough Beacon, in Sussex, only remains as a high hill in consequence of the ironstone in the sands of which the hill is composed, paving the brooks and keeping the water from touching the sand below. Ecclesbourn Glen (Fig. 24) is a good and accessible instance. The pieces of fallen rock pave the channel so as to resist the denuding action of the stream.

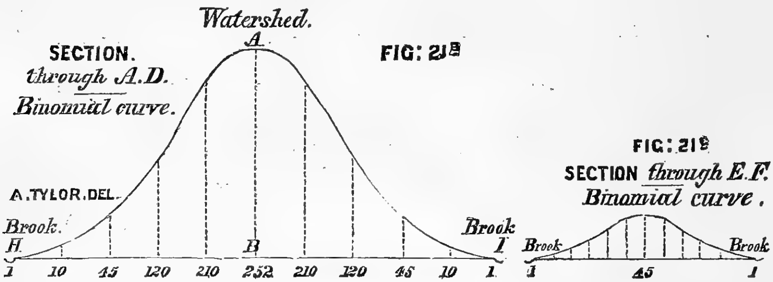


FIG21.D

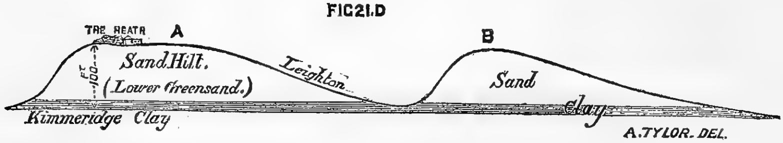
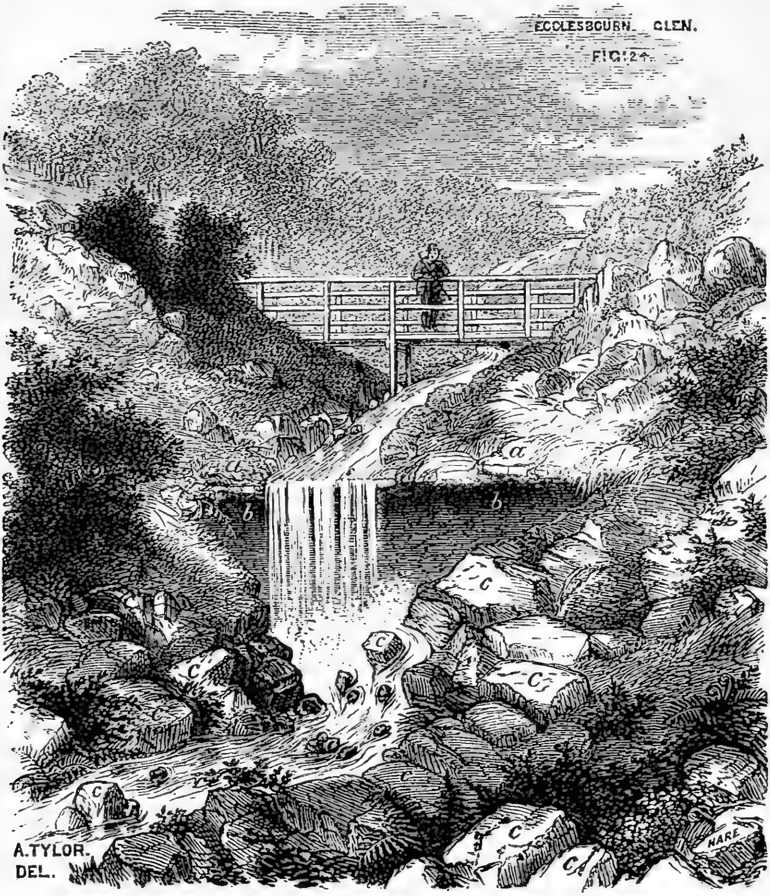


Fig. 23, p. 456, is a section through the waterfall Fig. 24 showing the bed of clay underneath the hard rock: water oozing through the joints of the stone passes between the stone A and the clay B. As the edge of clay at C is washed down, the stone at A falls there. This is the same case as Niagara, where a thick rock breaks vertically through the water from the lake above, passing below the Niagara rock and removing the base of shale.

(25) Fig. 24A gives a view of the Chalk hills near Folkestone, where small lateral valleys have been cut out by rivers flowing out of springs in the pluvial period. They are almost dry now, but were once of immense volume.

Fig. 24 represents the valley of Ecclesbourn, near Hastings, in the pluvial period.

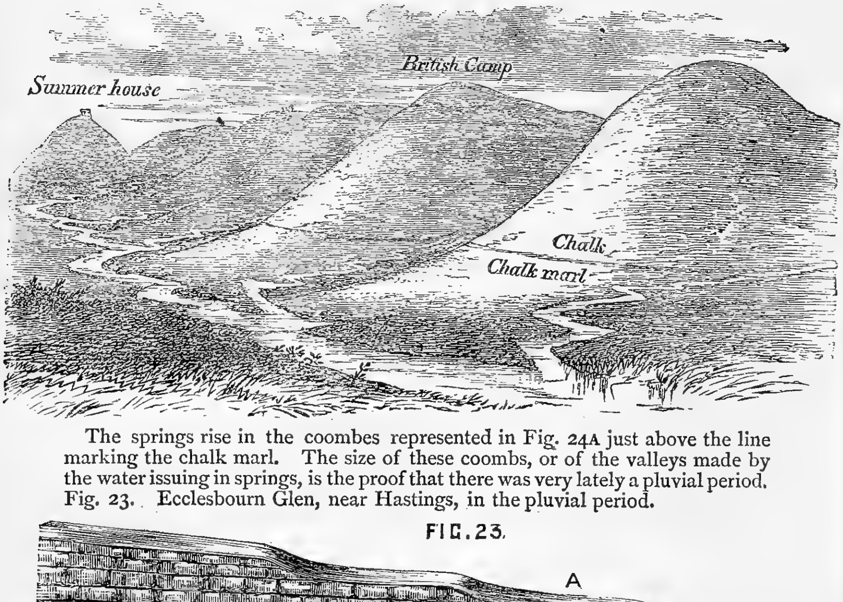
The model of Brading Gorge, in the Isle of Wight, shows that the rainfall, thrown off the lofty Chalk and Upper Greensand hills near Shanklin has, in comparatively recent times, cut a passage through the lower range of Chalk



and Upper Greensand hills near Brading. The higher elevation of the bed A (Fig. 25), caused by subterranean movement, is the cause of the direction of this rainfall collected into brooks from Ventnor to Brading. The same bed of Lower Greensand, at Shanklin, is 250 ft. above the sea; while near the Gorge of Brading it is at the level of the sea, giving a fall of 40 ft. in the mile. The level of the chalk is 500 ft. at St. Boniface's Down, near Bonchurch, and 300 ft.

on the chalk down above West Knighton. It is the coincidence of highest slope directing the water, and a low point in the escarpment or range of unstable beds that can be bored or undermined, owing to favourable transverse flexures bringing up the beds at a convenient level, that determines the position of a gorge.[5] (See page 457, Fig. 25.)

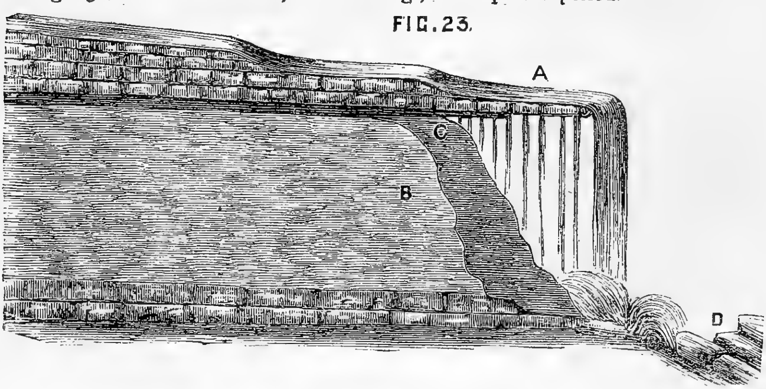
Folkestone in Pluvial period altered from a Drawing by
FIG: 24A. F. RUTLEY.



The springs rise in the coombes represented in Fig. 24A just above the line marking the chalk marl. The size of these coombs, or of the valleys made by the water issuing in springs, is the proof that there was very lately a pluvial period.

Fig. 23. Ecclesbourn Glen, near Hastings, in the pluvial period.

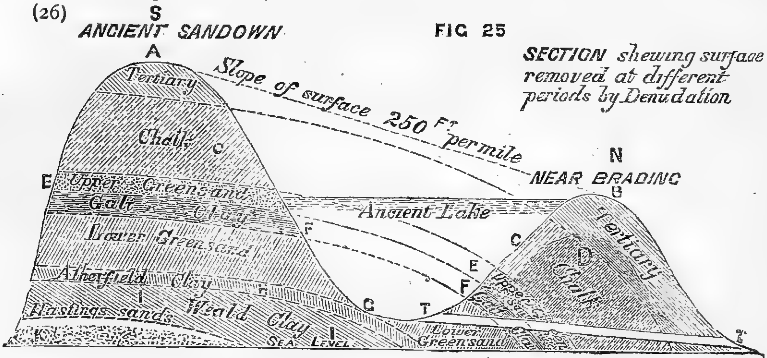
FIG. 23.



DENUDATION OF THE WEALD.

When a river attacks a range of hills and passes through them, it makes a passage at right angles to the direction of the range of hills, or to the strike, as geologists call it. It is always so, and I would give the six Wealden rivers as examples: the Mole, one of them, made the gorge, at Box Hill, at right angles to the strike or range of chalk hills, which form an escarpment from Guildford to Reigate, for instance.* In gorges or cuttings through escarpment, I observe that the dip is often with the stream, and thus assists the underground river, which did the difficult part of the excavation. I believe, in the first instance, a river on making a gorge always passes through an upper channel at a high level, and then boreas tunnel or cave passage at a lower level. Sometimes this is proved by a part of the arch of rock remaining, as shown in a

(26)



very beautiful drawing painted on the spot, by Arthur Severn, at Constantine, in Algeria. I have found a case in which both underground and overground channels remain, in Ystrad Vellte, in South Wales, near Hirwain. The rock is hard limestone, at the mouth of the cave 55 ft. high. On one occasion in the last two hundred years, there was such a flood that the water rose forty-five

FIG:27. Gorge through D.E. Chalk hills being formed.

FOREGROUND WEALDEN BEDS H AND K. A. SEVERN DEL.

feet up to the top. I have measured drawings of this interesting spot. The cave is one-third of a mile long. In a wet period, like the gravel or pluvial, the upper and lower channels would be used simultaneously.

I consider the steepness of the Cheddar Cliffs, and of the limestone gorge, at

* See Fig. 35, page 473, where the double set of flexures on the escarpment of the Surrey Hills are described.

Clifton, through which the Avon passes, is due to the ground having been perforated.[6] I believe the steepness of the cliff at Box Hill, 75° at the south-east corner, is due to the ancient cave, through which the waves passed, originally being at that point; and that the under-cutting below enabled the chalk cliff to be nearly as steep as at the sea shores, where the water has undercut, as at Culver Cliffs. This is the case of the nearly vertical cliffs at Cheddar; for when there was a tunnel, the roof falling in, left a vertical cliff above. There must have been very high ground at Bristol.

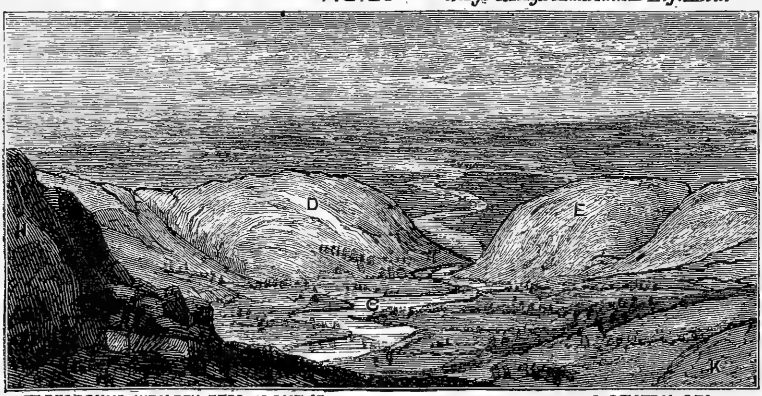
In a period with twenty to fifty times as much rain as at present, these underground passages for rivers would be formed with great facility, there being the assistance of 80 or 100 ft. head of water. We have the evidence from the pipes in the chalk, that this water was heavily charged with carbonic acid gas, although we do not know the source. Under such circumstances the Gorge of Brading would be easily made.

At West Knighton, two miles W. from Brading, an opening was being formed when the wet period ceased. You can see on the model the deep grooves being cut out by water. Every coombe is due to springs, and long escarpments, such as the Surrey Hills, or the escarpment of the Lias and Oolite, called the Cotteswold Hills, were being prepared for boring in this manner.

Figs. 27 and 28 represent what has happened at Brading.

Fig. 29A represents a limestone valley, Dove Dale, where the sides are very steep, owing to the greater stability of the carboniferous limestone than the sands (Fig. 29). The undercutting, by the river, nearly occupying the position of an old underground channel, is clearly shown. If Mr. Jukes had considered the method I have shown of the formation of gorges, when describing the Irish rivers Shannon and Blackwater, &c., I think he could have explained the causes of

FIG: 28 Gorge through Chalk hills D E formed.



FOREGROUND WEALDEN BEDS H AND K A. SEVERN. DEL.

their present direction more satisfactorily. His paper on rivers laid the foundation for the subsequent papers on the same subject by Prof. Ramsay.

The forms of valleys, lakes, and waterfalls affect and are affected by this special degree of motion of the water or ice, which modifies their forms, or causes what in mechanics is called instability. Indeed, valleys and escarpments with their springs, are integral parts of every complete river system. The earth and the water flowing over it must be considered at the same time, so intimately are they connected. They are related almost like the veins to the blood, and the sap vessels to the sap in a tree.

[5] See note, page 472.

I hope to show that rivers and lakes now occupy valleys and hollows formed when the physical and atmospheric conditions of our island were very different from those it now presents.

Ancient rivers may have had many hundred times as much destructive effect on the surface of the earth, for erosive force increases in the fourth power of the velocity, and may have eroded the surface of the earth as much in former times in one year as they now do in 1,000, in cases where rocks were made to slide on clay by excessive supply of percolated water.

I must ask you to assume what I have demonstrated many years since in another place, that all valleys, without exception, are enormously large, compared with the present rivers and brooks occupying them, and that the present size is the proof of the former rainfall or snowfall. This fact is visible to everyone in their walks or journeys, and the only inference from it is, that in the period just before man appeared, when the valleys were enlarged to their present size, the rainfall or snowfall was at least fifteen times as much as at present.

Figure 31 shows that rivers enlarge their channel on one side, the concave, and silt up on the convex side. The consequence of unequal rainfall is this movement of river channels in horse-shoe bends.

Some of these valleys were excavated in a very cold or glacial period by the action of enormous quantities of ice. Other valleys were excavated or enlarged by the action of ancient enormous rivers and springs of great power, in what I have termed the pluvial period.

Fig. 31 shows a case of a river changing its course in a flood 150 feet.

(27) FIG: 31. RUTMOO RIVER.

150 Feet Movement of river channel in one flood

Width, AA, 1450 feet From Sir P. Cautley page 22 1850

Figure 25 is a specimen of the action of springs, and represents the hills near Folkestone: at the present time most of these springs are very small.

These ancient streams were fed all over the globe by such rains as fall only in few places at the present time. In the Nile there are no tributaries at present falling into it for 1,000 miles from the delta, but there are dry valleys opening into the great Nile valley of enormous size, so that 300 inches of rain falling in the now dry climate of Egypt, would be carried away by the river, not without inconvenience, but without much difficulty.

The *Cyrena fluvialis*, now living in the Nile, was also found 120 feet above the present water level, at Silsilis, by A. Harris, showing that in floods in the pluvial period (which I consider that of man) the whole valley of the Nile, wide as it is, must have been charged with water up to 120 feet above the present flood level.

I think 300 inches of rain is the smallest quantity that could have fallen in a year, when the great masses of the Thames Valley gravels were deposited on ground where the present streams cannot move the old deposits.

That the present rainfall has not sufficient force to excavate new brooks and rivers in the London or any ordinary flat or alluvial district, I think will be admitted by all. There is no case of this kind known since the historical period, in the Thames Valley.

If I can prove the truth of the new law,* that with twenty-seven times the

* I first reduced this law to an equation from observation, and illustrated it by a diagram, in 1871.

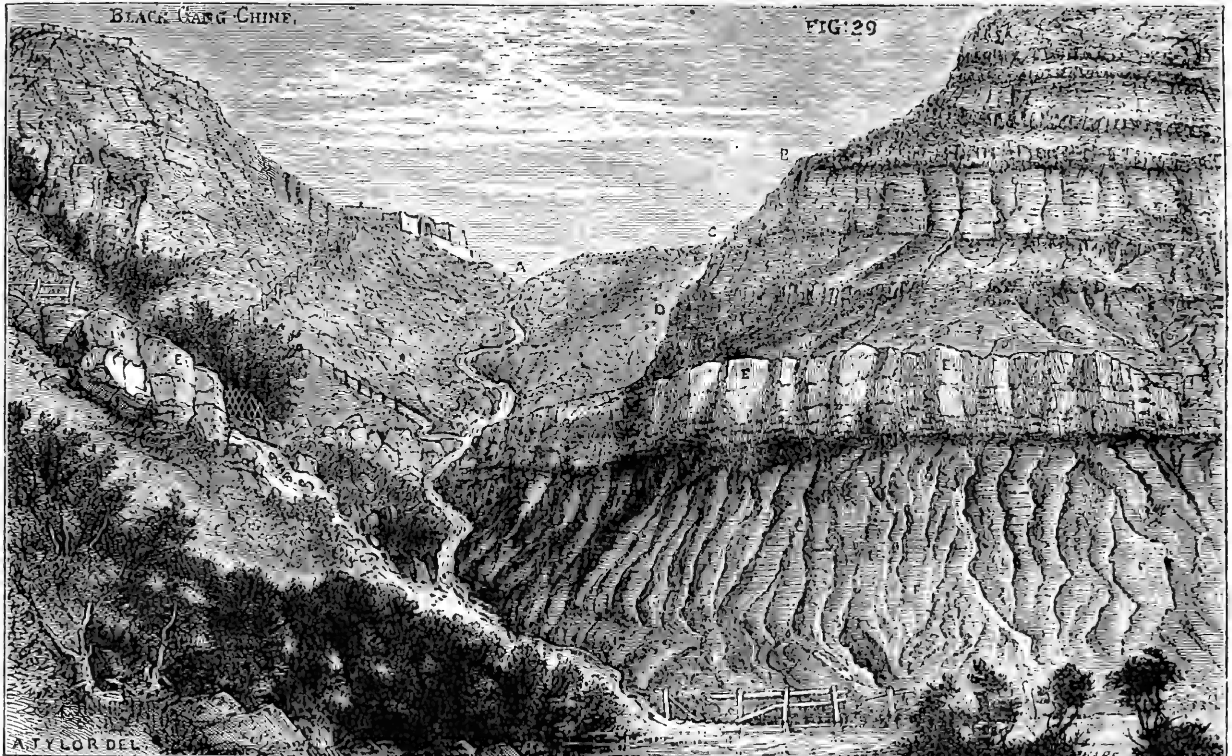


FIG. 29. Black Gang Chine, Isle of Wight, after a photograph, with more water than at present. The permeable strata *B*, *D*, and *E*, are stable beds forming walls with vertical faces and fissures for water to pass; *C D* and *D E* are slopes of less permeable strata. The alternations of wall and slope give the profile of a Gothic buttress in the soft rocks, exposed in a sea cliff, and are in this case as well marked as in hard rock in a less exposed situation.

FIG. 29a.

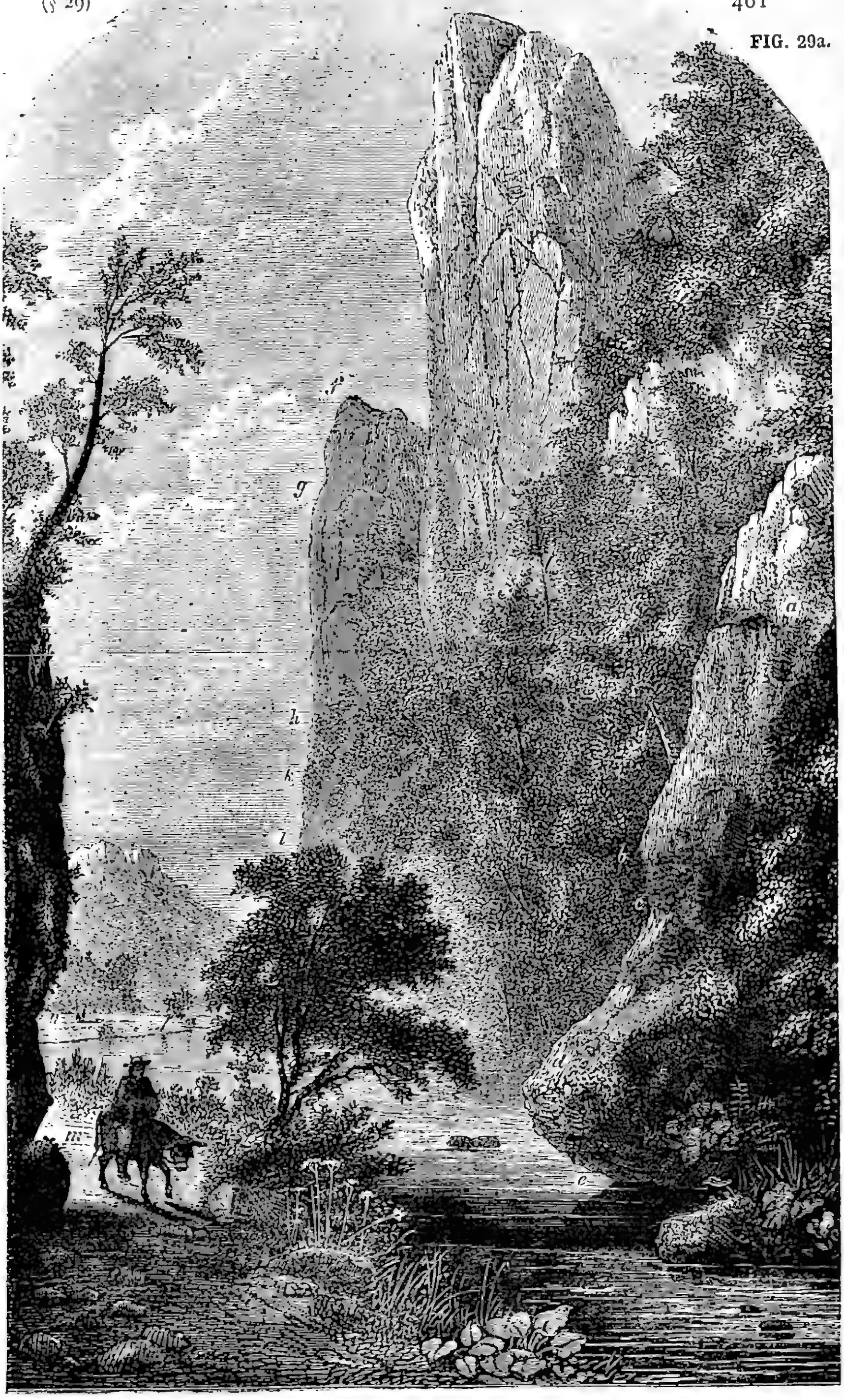


Fig. 29A. View of Dove Dale, Derbyshire. Showing undercutting in limestone rock at *a*, *c*, and *m*, by atmo spheric action, and at *e*, by indirect action of water. The undercutting shows in hard rock the varying stability o' the limestone, or the action of springs at those points. The same form or profile of alternating vertical wall and slopt at a lower angle is well marked in Fig. 29A. This is the same profile as a Gothic buttress, which is a shape wel adapted for stability under atmospheric influences.

rain, the brooks would travel with thrice the velocity they have at present, and if glaciers twenty-seven times higher would slide with a threefold velocity, then we have a cause which can sufficiently explain the erosions or lowerings by denudation during the glacial and pluvial periods.

The rounded London Clay hills in many places are curved like Fig. 19. The deposits of the large brick earth and gravel beds are conspicuous in the valleys of the rivers of the London basin, and the tracks of ancient rivers (as at Crayford) in the eroded surface of the chalk, now filled up with gravel and brick earth, may be seen in the excavations for brick earth. There are no beds of this kind now forming, and this shows that the present is not a guide to the past in the science of geology in many cases.

It is from these superficial accumulations of the pluvial period that the brick earth is derived, from which the building materials of this city are almost entirely derived, and the quantity of brick earth is a kind of measure of the intensity of the ancient rains.

Philosophers and writers of books on philosophical geology are always speculating about what are called remarkable phenomena, and very much neglect what occurs every day, and can be seen every hour. We ought to look at the low ground, as well as at the mountains. Being, as Mr. Pattison observed in a paper read at the Victoria Institute, March 1, 1875, more of an observer than a theorist, I would rather speak to you if I can, to-night, about what is the action of rivers and springs in places you know well.

The Fig. 25, page 457, is a type of the north and south flexures of the Weald. The gradient being so rapid north and south, the series of beds, Weald clay, Lower Greensand, galt, Upper Greensand, chalk, marl and chalk, crop out within two or three miles or less in the case of Guildford. In walking north and south you walk at right angles to the strike of the principal flexures. On the other hand, the east and west flexures are slight and always along the principal strike, so that you may walk along the out-crops of the same bed hundreds of miles. That is, you may walk along *the strike* of the north and south great Wealden flexures, which is of course E. and W., or in the direction of *the dip* in the small E. and W. flexures. The Wealden physical features are so difficult to describe because there are these opposite sets of binomial flexures, and what is strike to one set of flexures is dip to the other. There were evidently forces acting at right angles to each other when the Wealden was lifted up, each foot of surface having a simultaneous opposite flexure impressed on it, causing a double curve, affecting the whole depth of strata.

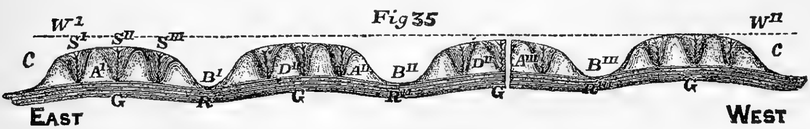


Fig. 35 represents the east and west flexures in the galt and Weald clay beds in the north escarpment of the Weald, which facilitated the original formation of the gorges through which the rivers run. This is explained in a note page 473. A river directed north against G would be repulsed by the clay, and have to flow east or west to B 2 or B 3 to make a gorge. Clay is very stable here.

There are a series of flexures east and west along the north escarpment of these Surrey hills, about 20 ft. per mile from Hildenborough to Maidstone, and 10 ft. per mile from Hildenborough to Dorking. The strata are only gently lifted and depressed in E. and W. direction 20 ft. to 10 ft. in a mile, while the great north and south flexures are near the gorges at gradients from 250 ft. to 1,000 ft. in a mile. It is this system of double flexures, one set in the medial series at nearly right angles to the other two sets, or marginal series of bends, that determines the denudations of the Wealden. I showed in 1862 (Quarterly Journal Geological Society) that the medial beds of Hastings sand thinned out N.E. and S.W. in a horizontal line passing from several hundred feet in thickness at Castle-hill, Hastings to 3 or 4 ft. 7 miles to the N.E. and S.W., and having a series of flexures in that direction.

It is only where a river carrying a large body of water attacked the point weakened and prepared by springs and underground river channels, that such an opening as the Gorge of Brading could be made. The ground at Sandown was formerly the highest on the island; now it is the lowest, owing to the instability of the upper beds of Lower Greensand reposing on the weald of clay at the level of the sea. This is the cause of the gorges of the Weald at Guildford. The Weald clay at Pease Marsh comes up there about 100 ft. above the level of the sea; and this has been the determining cause of the perforation at Guildford by the Wey, the Weald clay being 600 feet under Guildford. At Bury Hill the Weald clay is 250 feet high, and thus directed the Mole against Box Hill, where the Weald clay is 700 ft. under Box Hill. Then at Hildenboro, at the mouth of the Sevenoaks tunnel, the Weald clay was a solid mass 400 feet high, and protected Sevenoaks from the attack of the Medway. The gradient or slope of the Medway was too small for the river to bore at Hildenborough, and the river, therefore, changed its course at nearly a right angle towards Maidstone, and there resumed its original direction. Otherwise the Medway would have joined the Darenth if it could have succeeded in perforating a gorge at Sevenoaks. At Merstham there was an attempt by tributaries of the Mole to get through the chalk and join the Wandle, which was not successful. Thus one river had to pass to Maidstone, 20 miles distant, where the Weald clay was 400 feet less high in the direction of the escarpment of the Surrey Hills. Other rivers fell from 250 to 1,000 feet per mile, between Pease Marsh and Guildford, between Bury Hill and Box Hill, between Maidstone and Burham, and between Sandown and Brading, when these four gorges were formed. The high dome or elevated land at Crowborough determined one set of rivers, and another dome or elevated mass, called Hind Head Hill, near Haslemere, was the source of another set of three rivers going also in different directions, which have opened out gorges through the escarpment of the chalk similar to that at Brading.

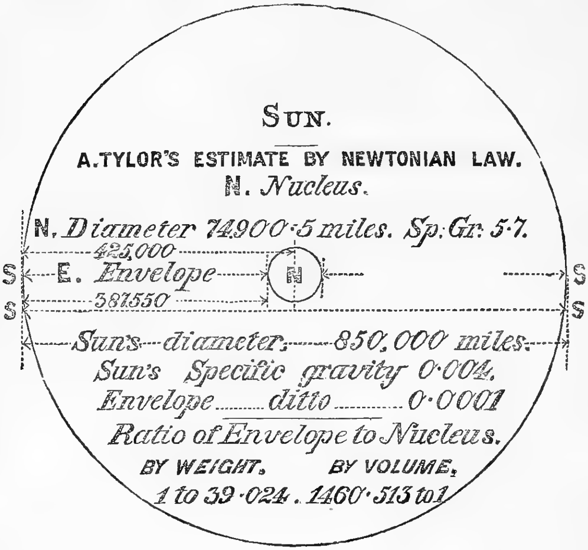
It was the fact of these two points being elevated higher than any other that started the Wealden rivers from them, just as the highly elevated ground in the Alps started the Rhine and other great rivers; and other and less elevated ground, like that near Donauessingen, started the Danube, and sent off smaller rivers to oppose the Rhine and keep it off Donauessingen. No doubt the Rhine now follows a course worked out for it by an underground river passing through the Devonian rocks between Bingen and Bonn. I find from Mr. F. Tuckett that the real springs of the Rhine are twice as high as those of the Danube. If a straight line was drawn to the Delta from the source of the Rhine, it would nearly touch the level of the springs of the Danube.

The sketch of the Gorge at Brading may realise what has happened there, and serve as a type of the valley excavations of greater rivers (Figs. 25, 27, 28).

PLUVIAL PERIOD DUE TO SUN'S INFLUENCE.

I have shown you the effect that great weight of ice sliding or water flowing has upon the velocity of ice and water currents, and that the enormous erosion of the surface of the earth visible in valleys and lake hollows could only have taken place when there were twenty times as much ice and snow as at present. These different atmospheric conditions point to some as yet unknown causes. Such snow and ice could only be formed by great heat in summer and great cold in winter. Some disturbing effect in the atmosphere of the sun could, I think, alone account for the phenomena we observe, and that must have been of a

FIG. 32.



periodical character. That is to say, the Earth must have received much less sunshine in winter and much more in summer. I calculate that the specific gravity of the sun is not more than 0·004, instead of 0·2543 as usually stated. If the nucleus of the density of the earth is 5·7, and if this nucleus is one-tenth of the whole diameter, then the density of the gaseous envelope of the sun would be only 0·0001, or about that of hydrogen gas. The weight of the sun seems to be enormously exaggerated. I do not find any careful calculation by any writer; and I only work it out as one-sixtieth of the weight that has been attributed to it. Chemical changes in the sun's envelope might produce great alteration in the sun's temperature. There is no reason to suppose the heat of the sun should be constant for any long geological period.

Also the series of rocks commencing with the Silurian, show evidence in every successive period of difference of conditions of life, and this evidence points to constant change in the quantity of heat and light emitted by the sun, and great alteration of atmospheric conditions.

Particular instances are the abundance of carbonic acid gas in the air during the carboniferous period, and again in the quaternary period. This is shown by Mr. Prestwich's paper,* investigating the cause of the eroded surface of the chalk, and is in one case proved by the rapid formation of coal, and in the other by the occurrence of deep pipes in the chalk, which appear to have been excavated by water containing a large quantity of carbonic acid gas.

The models and diagrams, however carefully executed, convey a very poor idea of real geological phenomena. Lectures are of very little use, except supplemented by observation in the field. The model of the form of the surface in the chalk at Brading gives an idea of the excavation of the gorge in the chalk

* Prestwich's Quart. Jour., p. 64, 1855.

between Dover and Calais, much as the drawing of the rivulet in Ecclesbourn Glen gives an idea of Niagara Falls. From close examination of small valleys we may learn a great deal about larger valleys. The abstraction of water to make ice for collection on the land in the glacial period must have dried the channels and coasts of England to what is now the hundred fathom line. I have many years since surveyed from Shakspeare's Cliff, the Channel—which I believe was once a watershed, bored and pierced by many rivers and brooks in a cold and afterwards very wet period: I can speak particularly of the effect of the landscape from Dover and from Cape Blancnez upon my own mind, and of the stillness of those treeless chalk downs—not plains of chalk, but a series of headlands and large coombes rising to 600 or 700 feet above the sea. In this watershed, now drowned, were once the sources of two large rivers or glaciers; one passing round the east coast of England and receiving the Thames, Somme,* Rhine, Maes, Scheldt, Humber, Forth, &c. as tributaries, and passing to the Hebrides; the other river or glacier at one time passing along the south coast of England, and receiving the Seine and all the small streams on the French north and English south coasts, having great waterfalls at the places where are now the races of Portland and the Channel Islands. This stream of water or ice met the perhaps frozen Atlantic near the Scilly Islands. It requires very little imagination when on these wonderful chalk cliffs to realise the extensive changes that must have occurred in the glacial period, when the German Ocean was obliterated, and when there was dry land to enable the Spanish plants to pass over to Ireland, the plants of Brittany and the Channel Islands to the south-west of England, the plants and land mollusca of Normandy to the south-east of England.

The longer connection by land of Guernsey and Belgium with the east of England enabled the flora and fauna of those countries to extend nearly all over England and Wales; while two-thirds of the Belgian reptiles got located in England, and three or four species crossed over to Ireland on dry ground, over what is now the Irish Sea.

Then the Scandinavian plants crossed to Scotland and Wales, and a few to Devonshire, remaining now in groups on the high land of Wales and Scotland. Anyone familiar with the existing glaciers of Switzerland and Norway, and with the lakes eroded by ice action, or with the remains of ancient glaciers in Snowdonia, and with the glacier-excavated lakes there, can realise in some measure the effect of the great glacial and pluvial periods, and can understand that it is hopeless to attempt to explain them in a lecture-room. I cannot admit the correctness of the authoritative statements in the "Principles of Geology," that we must not conceive greater forces than are at present in operation, although made by the eminent writer who has lately terminated a long life devoted to the study of geology. The geologists present in this room to-day, however much they might differ on all scientific questions, would all agree that very little is to be learnt in geology or physical geography without personal observation. And my advice to students is, not to rely upon books and lectures, but to use their own eyes in studying the sections and drawings.

I have now alluded to some of the points of the theory of uniform motion of rivers and glaciers. I attribute to the effects of gravity in inducing friction of ice upon ice, in lake and other great glaciers, enormous excavations in the ice period. This closed at a date not far from the historical period in some parts of Europe, while in other parts there was at the same time a pluvial period. †

---

* Godwin-Austin, Quart. Jour., 1850-51.

† Mr. Croll is quite in error in stating that geologists considered the glacial period occurred a million years ago: only one geologist and his followers held that opinion. Jukes, for instance, in 1862 considered the glacial period quite recent. Prestwich thought that the quaternary gravels were post-glacial, but he gave no estimate of such a time as Croll indicates, nor did

The quantity of water flowing is an important element in computing the change of surface, whether in a cliff or a waterfall. The stream at Black Gang Chine (page 460) is very small at the present time, but if eight times the quantity of rain fell, and the velocity was doubled, the power of the surface stream would be much increased. This is, however, only one element. The water from each flat watershed descends under ground and escapes in springs, and springs in a wet period have been the great denuding agent. The action of denudation by underground watercourses has never been sufficiently estimated or properly calculated.

The contour of surface depends upon the resistance of the strata to the rainfall. The terrestrial surface of the earth is always a succession of terraces and flats, or rather walls and slopes. This is what we call "contour." In some districts, where the walls are very conspicuous, we call the ground terraced. Where the walls are low they often escape observation. Water produces, equally, lofty and nearly vertical walls in some permeable beds, and low surface slopes in other impermeable beds, or it produces a succession of infinitely small walls and slopes, which to the eye appear like a plane or curved surface.

These are questions of mechanical stability or instability. (Denudation is Instability. See page 487, Geological Magazine, 1872.) The load, the quantity of water, and the direction of the strata, are elements which affect the coefficient of instability. Spring water is the most destructive agent, as the water flows out of the ground, at times under pressure, underholeing, or undermining the most solid rocks, and letting immense masses of rock and sand fall down from the sides of the valley into the bottom, to be carried away by rivers. Anyone who has seen the slips all along the top out-crops of the impermeable fire-clays in a Welsh valley in the coal measure series, when there is ten inches of rain in a month, will be able to estimate the enormous denudation in the pluvial period (see page 487, Geol. Mag., 1872), when there was 300 inches of rain in England in the low districts, and probably two or three times as much on the mountains.

I shall continue these observations at a meeting of the Geologists' Association, June 4th next.*

---

any other independent geologist but Lyell hold these opinions. Sir R. Murchison in his address to the Royal Geographical Society in 1863, said almost all geologists were agreed as to man having made his appearance in a very recent and in a glacial period.

* Quarterly Journal, 1868, p. 394. Geological Magazine, 1872.

APPENDIX.

From the equation $Q = AV$ (using Q and q for discharges per second, and A and a for cross sections, and I and i for slopes), and from observation, I have

$$\frac{v}{V} = \sqrt[3]{\frac{q}{Q} \cdot \frac{i}{I}} \text{ (2), and } \frac{v}{V} = \sqrt[3]{\frac{a\ v}{AV} \cdot \frac{i}{I}} \text{ or } \frac{v}{V} = \sqrt{\frac{a}{A} \cdot \frac{i}{I}};\ldots(3)$$

from which I obtain a new equation to the flow of water in uniform constrained motion—that is, only when $V = v$. This is true for any slope with the same material of channel,

Then from (2), when $\frac{v}{V} = 1$ then $\sqrt[3]{\frac{q}{Q}} = \sqrt[3]{\frac{I}{i}}$ or $\frac{q}{Q} = \frac{I}{i}$.

Then from (3), when $\frac{v}{V} = 1$ then $\sqrt{\frac{a}{A}} = \sqrt{\frac{I}{i}}$ or $\frac{a}{A} = \frac{I}{i}$.

Then by compounding in the very general case when water is in uniform motion we have the formula

$$\frac{I}{i} = \frac{1}{2}\left(\frac{a}{A} + \frac{q}{Q}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

It applies to water in canals in uniform motion, as in Figs. 6 and 7, page 446. Coefficients have to be used for each different material of channel, which are here omitted. They are found by observation.

The effect of motion in diminishing pressure is an important physical cause; this appears to have been overlooked. I quote some remarks on this subject in relation to the barometer, because they have a general bearing on all physical questions where pressure is modified by motion.

From the QUARTERLY JOURNAL OF THE METEOROLOGICAL SOCIETY, *for January*, 1875.

Mr. A. TYLOR said he should like to offer some evidence to prove that the barometer cannot be considered a correct instrument for registering the absolute weight of the atmosphere, although it often indicates the relative weight correctly. The absolute pressure on the cistern of the barometer varies much more for horizontal motion of the air than it can for mere change of weight of the atmosphere.* By analogical reasoning from his experiments on the Injector, described page 215, Phil. Mag. September, 1874, he stated that the column of mercury in the barometer shortens for motion instead of lengthening for weight. There is a constant fall in the barometer during the formation of clouds and condensation of vapour into rain in temperate climates, where the rain-making process occurs in the lower strata of the atmosphere. The mixture of dry air and vapour at 40° would cause a change only of 8 parts in a thousand in volume, and yet would cause a considerable lateral and vertical displacement and movement in the atmosphere. The change in absolute weight of the atmosphere under these circumstances would be comparatively slight, and would not account for a fall in the barometer of 0·3 in. or 0·4 in., or 3 per cent. (or 30 parts in a thousand), which is frequent in England during the process of rain-

---

* Professor R. Tennant, of Glasgow, informs me he has read a paper recently at the Royal Society of Edinburgh (which will appear in their Transactions), "On Meteorology," containing a view of barometric action. From the abstract sent this appears to be similar to my own.

making. Then, directly the rain has fallen and the air becomes quiescent, the barometer rises again; the influence of motion having ceased equilibrium is nearly restored. In tropical countries, where rain is formed at a high elevation above the ground, the horizontal movements in the upper strata are masked completely by the actual rainfall near the surface, tropical rain making in its fall vertical currents in the direction of the ground, thus causing the barometer to rise because it actually puts an extra line of pressure on the cistern. In the Doldrums, it is well known that the winds meeting near the sea-level constantly mix and cause an upward current, accompanied by condensation of vapour. The barometer is therefore always a little under 30 inches, not because the atmosphere is lighter there than elsewhere, but because there is horizontal motion across the column caused by the generation of rain, and motion upwards caused by the expansion of the air vertically. The two different causes produce the same effect in diminishing the actual pressure on the cistern of the barometer. It is possible with a velocity of ten miles an hour, in an artificial current of air or blast in a fan to depress the barometer 0·1 inch, independently of any rarefaction or condensation of the air itself. This would cause a fall of 0·5 in. for a current of fifty miles an hour if the barometer fell in like proportion. This rate would accord with that observed in atmospheric

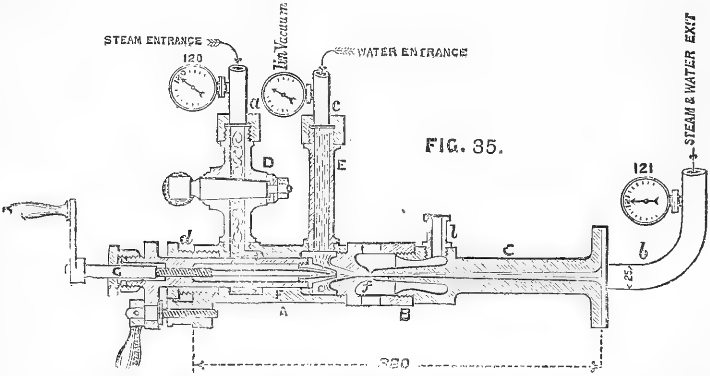
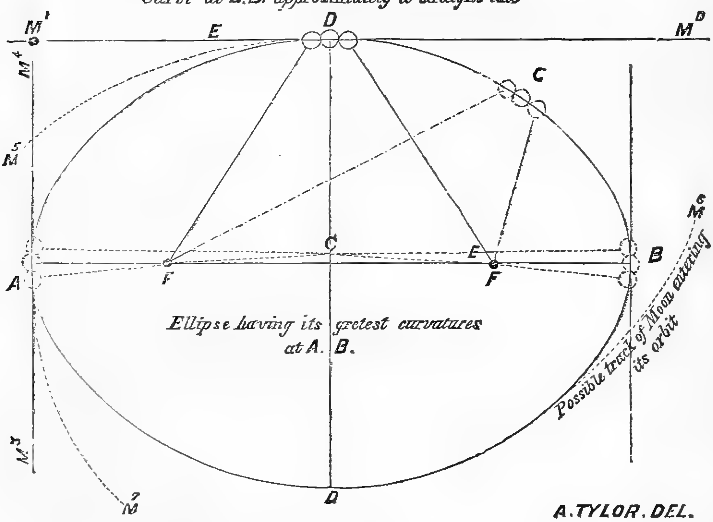


FIG. 35.

storms when the force of the wind is fifty miles per hour. He thought no change of mere weight of atmosphere could cause the barometer to fall 1·693 in. as happened in Guadaloupe in September, 1853; or at Bromley 1·0 in. on November 29th, 1874; or 1·21 in. at Guildford at the same time. This result or fall, showing great diminution of pressure, was perhaps equally due to sudden condensation of vapour causing local currents, and to the strong winds derived from distant regions causing horizontal motion across the column of air, and reducing pressure on the cistern of the barometer and causing the column to shorten. Then, on the contrary, in London, on December 1st to 14th, 1873, the barometer averaged 30·5 inches, the atmosphere being excessively still, and fog continuous. Directly rain occurred, on the 15th, the barometer fell for motion in the air. In his experiments on the Injector, described page 215, Phil. Mag. 1874, he found that in the body of the Injector there was 121 lbs. of pressure by the gauge, accompanied by rapid motion of the steam, yet, in an adjoining tube, connected with the water tank opening at a right angle into the Injector, there were two inches of vacuum according to a water gauge. The experiment shows that within an inch of distance of a current of steam at 101 lbs. pressure by the gauge, there was actually an open water pipe with a partial vacuum and a slow motion. This shows how much fluid motion in one direction can influence pressure and motion in another. In Fig. 35, the Injector, the friction of the steam against the metal raised the temperature 0°·17, and the pressure 1 lb. above the pressure in the boiler, and yet made a partial vacuum in an adjoining stratum of fluid, that is, in the water-pipe. This experiment is a proof that the barometer cannot give a true indication of weight when there is motion in the atmosphere. The Injector is a case strictly in oi nt; the currents of steam and water not being separated by any valves, are true types of the contrary currents occupying adjoining strata in the atmosphere.

The drawing, Fig. 35, page 468, represents an ordinary injector. About 60 experiments were kindly made for me by James Cudworth, C.E., at Ashford, to determine the state of the relative pressures in the boiler, injector, and water-pipe as soon as the water began to enter the boiler. The currents at different levels and different direction in the atmosphere may affect the barometer much as different currents of steam when the boiler pressure change very rapidly affects the reading of the barometer. The results of the experiments were that in passages connected with each other there was a difference of 100 lbs. in pressure. The direction of motion of the fluid in one part of the apparatus entirely modified pressure in another part.

FIG 33
Curve at D.D. approximately a straight line



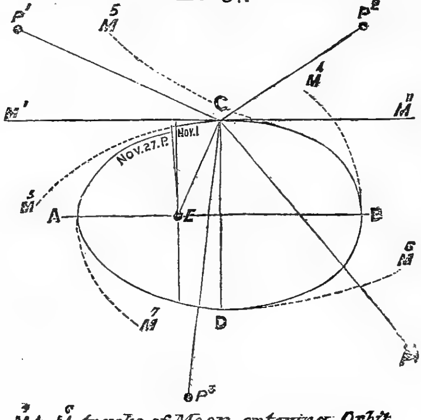
SUN'S ATTRACTION.

The question of the effect of the sun's heat on different parts of the earth no doubt depends upon the angle at which the ray or heat-vibration from the sun strikes each part of the earth; but the question of the time and motion of each square foot of the earth's surface is exposed to the sun's rays should also be taken into account. We know that the effect of the chemical rays depends very much upon the object being still, and on the duration of the attacking series of chemical rays or vibrations on the exposed surface in the photographic progress. The sensible sun's heat rays may be in proportion to the time each heat ray or vibration reaches the earth or is in action, as well as to the distance. This may help to explain why the sun's heat is least when the earth is nearest to the sun, for the velocity of the earth is then greater: the angle of incidence of rays also varying.

Fig. 36 represents an ellipse or orbit with the large attractive body at the point F, one of the foci of this ellipse. M′ M″ are smaller bodies supposed to be deflected from the straight line along which they were projected, by the force of the great body at F. It will be seen by reference to Fig. 37, that the orbit cannot be a true ellipse which any body M′ or M″ will follow. The reason is that the curve in the ellipse is really greatest at A, while it approaches a straight line at D. Attraction from a single force, F to M, could not produce such a result, which would only occur if there were another attracting body of equal size at the other focus F; that is, an ellipse is a two-centred curve and has none of the properties of the single-centred orbital curve Fig. 37.

Orbital curve not an Ellipse.

FIG. 37.



M to M tracks of Moon entering Orbit.

A. TYLOR. DEL.

Fig. 37 is an orbital curve in which the earth moves round the sun supposed to be stationary, or in which the moon moves round the earth when that body is supposed to be stationary for the purpose. The deflection of the small body M, M, M, &c. (from a straight line), projected into the orbit, is in proportion to the weight and nearness of the small attracted body M, M, &c., to the great attracting body at E. The orbital curve at A is greatest because the force E is nearest to that part of the curve, and therefore E deflects M (extending its orbit and continuing it in the track) most from a straight line. In Fig. 37 the attractive force from E is at its mean at C and D, and therefore the curve at those points is at its mean at C and D. The gradient or slope of the orbital curve is at its minimum at B, because E can deflect the small body M^4 least at B from a straight line. The gradient or curve is greatest at A, because the attractive force at E can deflect the small body M the most from the straight line in which a body like the moon or earth was originally projected through space.

It would continue moving in a straight line except when deflected by attraction, and therefore the curve of deflection, or orbital curve, may be considered as the resultant of the two forces. The orbital curve is really to be treated as a case under Law 3, Cor. 1 and 2, B. i. Principia, where the law of the parallelogram of forces is stated. As the orbital curve is not an ellipse, Prop. xvii. prob. ix. B. i. Principia does not apply. That proposition only applies to conic sections. The shape of Fig. 37 proves the orbit of the earth or moon cannot be a conic section. Why the orbit of the earth was ever treated as a conic section is difficult to understand. By calculating the gradients of the orbit—that is, the curve at different points—I find the curve is much more egg-shaped than elliptical. In all the drawings of the orbit of the moon, where the earth is considered stationary, from the times of Kepler to Procter, I find the orbit drawn as an ellipse, with the curve at B Apogee and A Perigee—the same gradient, if I may use that term. I find, however, that at A Perigee on the 22nd November, 1874, the gradient of the curve was 0·01185 of a foot in a mile, while at B Apogee on the 9th, the gradient was only 0·01047 of a foot in a mile. On the 15th, when the moon was near the mean distance for the month, D the gradient was intermediate, or 0·01082 feet in a mile. In an ellipse at mean distance C or D the curve would be almost imperceptible, and also would be of equal gradient at B Apogee and A Perigee. The same general remarks apply to the orbit of the earth round the sun. I have shown the point P on the 27th of November, 1874, nearer the earth, Fig. 37, than on the 1st by a considerable distance. After the whole lunation on the 27th November, when the moon is in the same position as to angle as that which is occupied on the 1st November, as regards the earth, the moon is less distant. This is indicated in Fig. 37 reduced from large drawing in which I calculated the distance of the moon for each day. Fig. 37 is a complicated curve, not a conic section; I have called this the orbital curve, the velocity and gradient decreasing from A to B through C and increasing from D to A through C in a simple ratio.

NOTES.

[1] *Note to page* 439.—Ice acts as a colloid in promoting the passage of vapour or of water into the interstices of cells, and thus produces the cold necessary for regelation, by evaporation of water. Directly the spaces are filled the contrary action ensues, and that is the reason why there is no regelation when there is no superfluous water to melt the ice in contact with it, or too much water. With ice (if possible) frozen of the specific gravity of water in an hydraulic press, regelation would not occur, as there would be no air cells or colloidal ice. As wet ice regelates and freezes to flannel, the explanation of regelation cannot be that it depends on cohesion or attraction of surfaces, except so far as these affect evaporation and condensation of vapour.

[3] *Note to page* 442.—Fact mentioned by James Giekie, Ice Age, 1875.

Note to Fig. 9, *page* 447.—

Channel	A B	B C	C D	D E	
Discharge	0·203	0·307	0·618	1·236	Mean velocity nearly equal in the four channels, notwithstanding difference of slope.
Velocity	1·278	1·259	1·325	1·348	
Slope	0·00824	0·049	0·00208	0·0015	

The observations were made by Darcy and Bazin, 1868, without any view to this theory. Recherches Hydrauliques, Paris.

Note to Fig. 10, *page* 448.—I calculated in 1853 (Phil. Mag. p. 264) that the solid matter in suspension in Mississippi water indicated a denudation of the whole surface of 1,240,000 square miles (the area drained by that river), of 1 foot in 9,000 years. By taking into consideration the siliceous matter carried beyond the Delta, which I omitted, and estimating the proportion of quartz rock to clay slate as 2 to 1, in the district under denudation, I now calculate the average rate of denudation in the Mississippi area (which is supposed to be the average of the world) at 1 foot in 2,000 years, of which 8 inches is siliceous matter, and the other silex and clay in the proportion they are found in clay slate. The usual proportion of silica and alumina in the solid matter suspended in river water is that in clay slate, according to Bischoff: that is, silica 65·1 and alumina 16·38 per cent. in clay slate. In the Rhine water Bischoff found the sediment, or matter in suspension, composed of 63·77 silica and 15·54 alumina. On the contrary, in the Permian beds he found silica 97 and alumina 2 per cent.

The proportion in the rocks of the globe of silica and alumina gives a means of calculating the rate at which the whole surface of the earth is lowered. The wetted perimeter at Fort St. Philip, Mississippi, is 2,576 feet. If the sand on the river bottom and channel moves out to sea 1 foot deep at 10 feet per minute, twice as much material will be conveyed beyond the mouth of the river along the bottom as is carried away in suspension. Colonel Tremenheere, in 1866, made a series of observations on the movement of water coast-ways on the coast of India. He found a constant current in one direction at a mile an hour, taking floats from the Indus' mouth right into the harbour of Kurrachee. Mr. Croll has entirely omitted from his calculations the enormous mass of sand pushed out or carried out to sea by rivers, in his late estimate of denudation in climate and time. He has also mistaken the figures, I printed first, of the coast line of continents, for the coast line of the whole world. In Phil. Mag. 1853, I gave Fig. 3, page 263, the proportion of the coast line of the whole world, and made an estimate of the denudation by the sea, taking the coast line of islands as twice as much as continents. Mr. Croll has varied my figures, and arrived at a conclusion that no one could admit as to denudation. I consider that after a long denudation the coast line would be very much lengthened, and the surface of the land would be as much raised by blown sand and coral banks as it was lowered by other actions.

[4] *Note to pages* 442 and 449.—Dubuat has been misunderstood on this subject by Mr. Croll. Dubuat limited his remarks on the relation of motion to slope to the case of a little canal, and never intended his remarks to apply to the relative motion and slope of the ocean. Mr. Croll's argument on this point with Dr. Carpenter is unfortunately based upon an incorrect reading of Dubuat, and cannot be maintained.

[5] *Note to page* 456.—The Niagara limestone is 80 feet thick, lying on the Niagara shale, also 80 feet thick, according to Dana, where the Niagara waterfall is 60 feet high. The covering of the shale by falling blocks of limestone, is not noticed by him, although it must be, I should think, an important feature.

[6] *Note to page* 457.—The gradient from the surface of the Weald clay once upon Crowborough Beacon (then 1,700 feet high), in the direction of Sevenoaks Weald, near Hildenborough (400 feet high), close to the south end of the Sevenoaks tunnel, was a comparatively flat surface, about 80 feet per mile; that is, the fall, from 1,700 feet to 400, or 1,300 feet in 17 miles, is 80 feet per mile; while in the gorge at Dorking the Weald clay falls 800 feet in a mile. In one case there was a watershed and a small denudation, in the others a river and great removals, owing to the difference in dip favouring denudation.

[7] *Note to Fig.* 35, *page* 462.—This wood-cut, Fig 35, and accompanying explanation, was set up in type by Mr. Anstin, of Hertford, in 1872 for the Geological Magazine. My paper on denudation, with allusion to the Weald, was being published, but the end of that paper was cut off for want of space, including the illustration. I reprint this on page 473 from the proof of 1872 without alteration.

Fig. 34 is a section of a river perforating an escarpment from north to south. The dip may either be north or south, without altering the form of the escarpment streams S^{I} to S^{VI} flowing from E. to W. or W. to E. The Wealden rivers flow with the dip; the Avon, at Clifton, flows against. The strike, here represented east to west, appears to be important, as, whatever the dip may be, the river enters the escarpment at a right angle. It can make most progress in denudation when it strikes the strata directly, and not obliquely.

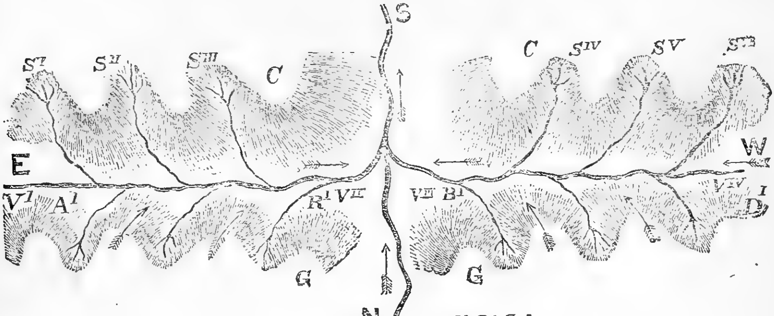
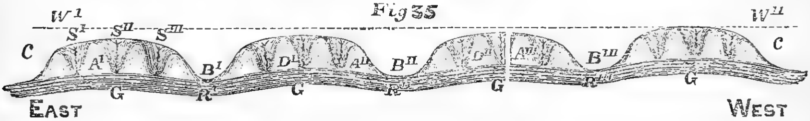


FIG: 34.

The Streams S^{I} to S_{VI} are shown entering the side river, or banks, V_{I} to V^{VI} at an acute angle, and these enter the main stream, near R^{I} also at an acute angle. In a paper sent to the Institute of Civil Engineers, February 1872, the author has discussed the question of river junctions. The stratum shown south of the streams V^{I} to V^{IV} is intended for chalk, and is shaded so as to show the higher elevation of the source of the streams, S^{I} to S^{VI}, in consequence of the greater stability of the chalk, than those flowing from G, the Gault clay containing those streams. It will be observed that the stream S^{I} flows nearly north, then west, and then south. The streams flowing off the Wealden Escarpments take such a course that they, after a few miles, flow in an opposite direction to that they first followed. Fig. 35 represents this general fact. The height of the main stream at V_{III} depends upon the distance and relative levels of the Watersheds, and of the point it discharges at into the sea or great river. The longitudinal flexures of the pervious and impervious beds, and the general direction of the side streams also, upon the quantity of water flowing, determine the exact position of the Weald and other rivers. The course of the side streams is determined often by flexures of the strata and Watersheds, so that it is a complicated problem, but not an impossible one, to find the theoretical course of a river under certain known conditions.

Fig 35



This diagram shows the effect of transverse flexures on the Weald clay, or Wealden valley, combined with similar flexures in the Lower Greensand, in determining the particular points of the Wealden escarpments to be perforated by the Wealden rivers. The rivers Wey, Mole, and Medway R^{I}, R^{II}, R^{III}, flow at the bottom of the traverse binomial curves B^{I}, B^{II}, B^{III}. The great flexure near Holdenborough, for instance, raises the Weald clay to a much greater elevation there than at a point at Dorking.

LIST OF SCIENTIFIC PAPERS BY A. TYLOR, F.G.S.

And Short Reference to their Contents.

1. On the Occurrence of productive Iron Ore in the Eocene Formations of Hampshire. Quarterly Journal Geological Society, vol. vi. page 133, 1850.
2. Full Abstract "On Changes of the Sea Level, and on Denudation." Contains method of computing present rate of denudation of the land from present fluvial and marine action, by estimate of material now carried out to sea by rivers and removed from cliffs by the sea. That there were larger rivers and more rainfall and denudation in former periods. Philosophical Magazine, pages 258—274, April, 1853. Taylor & Francis, London.
3. Short Abstract of above. Vol. ix. page 47, in Quarterly Journal Geological Society, 1853.
4. Full Abstract ditto. Silliman's Journal, vol. xviii., pages 21 and 216. New Haven, U.S., 1854.
5. Ditto, ditto. Canadian Geological Journal, 1854.
6. Report on General Metal Work in Paris Universal Exhibition, 1857. Jurors' Reports. Part I., 101 pages. Eyre and Spottiswoode.
7. Part II., ditto, ditto, 48 pages. Supplemental Report, General Metal Work.
8. Part III., ditto, ditto, 17 pages. "The Education of Workmen and the Improvement of their Social Position." This work contains a statistical account of the number of manufacturers in business at a specified time, distinguishing those who have commenced life as workmen from those who have commenced with small or large capital. The accounts show that the proportion of existing manufacturers is in the same proportion as the same classes in the whole population.

8A. Articles on Metal Work, Ure's Dictionary, R. Hunt, F.R.S., Editor's Edition 1860. Founding, &c., &c., Longman.

9. On the Footprints of an Iguanodon, lately found at Hastings, and its Position in the Wealden. Contained new view of the horizontal thinning out of the Hastings sand series, on each side of Hastings, and of the relative position of the Weald clay between Pevensey and Eastbourne. Quarterly Journal, Geological Society, page 247, 1862.
10. Rolling and Casting of Metals, 8 pages, 4to. Contains comparative view of regelation of ice and of welding metals, both processes being as dependent upon the colloidal structure of the material. Practical Mechanic's Journal. Record of the Great Exhibition of 1862. Edited by R. Mallet, F.R.S.
11. Report on Class XXXI., Metal Work. Part I., 13 pages, 1862 International Exhibition Report. Bell and Daldy, 1862.
12. Part II. ditto, 37 pages, ditto, ditto.
13. Part II. Education and Manufactures, 2nd edition. Reprint from Jury Report. Scientific and Art Education in relation to Progress in Manufactures. Education in England. Longman, 1863. This was one of those works on education selected for examination and used by the Lord

Advocate during the preparation of the Scotch Education Act, which passed Parliament in 1872-3. The Lord Advocate used the argument in page 36, 2nd edition, 1863, in replying to the objection that illiterate men were not fit to choose school boards. On page 36 it is shown that electors, (among whom are many uneducated) choose members of Parliament—that is, the less educated classes select the more educated men. Also, that parents are more fit to choose proper persons to manage schools than the rich educationists, who subscribe to schools to get their own particular views on certain subjects thrust on to the mass of the people.

14. Jury Report translated into Swedish, by Dr. Andreas Grill, President of Board of Ironmasters, Sweden, 1863.

15. "Industrie und Schule." Mittheilungen aus England, von Alfred Tylor, auf Veranlassung der Königl. Wurtemburgsche Centralstelle von Gewerbe und Handel. President, Dr. von Steinbeis, deutsch bearbitet von Dr. Bernhard v. Gugler. Stuttgart, 1865.

16. On the Discovery of supposed Human Remains in the Tool-bearing Drift of Moulin, Quignon. Anthropological Review, 1863, pages 166—169. The authenticity of this specimen was doubted, and the suggestion made, page 168, turned out to be correct, that the human jaw had been removed from an old Frankish cemetery and buried in the ground by the workmen.

17. On the Interval of Time which has passed between the formation of the Upper and Lower Valley-Gravels of England and France. Vol. xxii. pages 463—468, Abstract Quarterly Journal Geological Society, 1866. This paper contains the view that what were termed High and Low Valley-Gravels were of one age, and close to the historical period.

18. On the Amiens Gravel (Abstract, page 1) and Paper, pages 103—125, vol. xxiv. Quarterly Journal Geological Society, 1868.

18A. Ditto, Geological Magazine, December, 1867. This paper contains the first suggestion of Pluvial period, page 105.

19. Das Amiens, Geröll aus Alfred Tylor, Gelesen den 8th November, 1867. Neues Jahrbuch, vol. xviii. pages 129—137, 1868. Leonhart & Geinitz, Stuttgart.

20. On Amiens Gravel, The American Journal of Science and Art, vol. xlvi. pages 302—327, New Haven, U.S., 1868. Dana, Editor.

21. On the Quaternary Gravels of England (Abstract). Vol. xxiv. page 455, Quarterly Journal Geological Society, 1868.

22. On the Quaternary Gravels of England. Vol. xxv. pages 57—100, Quarterly Journal Geological Society, 1869. This paper contains, page 63, calculation of volume of flood in Gravel period one hundred and twenty-five times that at present in the same valley, and the calculation that rivers were twenty times (or more) larger than at present, page 59.

23. Discovery of a Pleistocene Fresh-water Deposit, with Shells, at Highbury New Park, near Stoke Newington. Geological Magazine, 1868, vol. i. page 391. The flint implement engraved by Mr. Evans, Ancient Implements, page 525, was found by me among loose materials in this pit, probably brought with chalk and sand from another part of the Thames Valley. I showed this specimen to Mr. S. Skertchley, and other persons at different times, believing it to be a remarkable fractured flint. Mr. Evans visited the pit afterwards, found the flint where I had been working for shells, and at once identified it as a real flint implement. Very few instances are known of the occurrence of flint implements in the Thames Valley, where it is expected they would be most abundant.

24. On the Formation of Deltas, and on the Evidence and Cause of Great Changes of Sea-Level during the Glacial Period (Abstract). Vol. xxv. pages 7—12, Quarterly Journal Geological Society (read November 11, 1868), 1869. This abstract contains, page 9, suggested rainfall 300 inches in Gravel period; the law of parabolic river curves; the proof of ocean level being lowered 600 feet in Glacial period, by removal of water to form ice on the land; binomial curve of denudation; sections in the Modern Delta of Venice, &c.

25. On the Formation of Deltas and on the Evidence and Cause of Great Changes in the Sea Level during the Glacial Period, with Appendix. Vol. ix. pages 392 to 399, and 485 to 500, Geological Magazine, 1872. This is the paper printed as read at the Geological Society's meeting, November 11, 1868, with an Appendix bringing up the subject to 1872.

25A. Drawings for Improved Ventilation of Mines, Measuring Apparatus, and Laws regulating Flow of Air and Water, 1870 and 1871.

26. On Tides and Waves (Deflective Theory). Pages 204—219, Philosophical Magazine. Taylor and Francis, London, 1874.

27. Remarks on the Effect of Motion in diminishing Pressure, illustrated by the fall in the barometer for motion in the atmosphere, whether caused by motion of air in storms, or by condensation of vapour causing motion in atmosphere during rain-making. Pages 279, 280, Quarterly Journal Meteorological Society, January, 1875. Williams and Strahan, London, 1875.

28. Lecture at London Institution, March 11, 1875. Lecture Supplement to Journal of London Institution, No. 26, pages 27—48, 1875.

29. Ditto, ditto, Reprinted with Additions, September 1. Supplement, Geological Magazine. Trübner.

30. Lecture on Hill and Valley Formation and Laws of Denudation and Rivers, at Geological Association University College, London, June 4th, 1875.

ERRATA.

Page 436, line 7, *for* page 26 *read* page 456.
,, 436, ,, 27, *for* page 32 *read* pages 462 and 473.
,, 439, foot-note, *for* page 40 *read* page 471.
,, 443, ,, 27, *for* Caut*t*ley *read* Cautley.
,, 445, *for* Section at "Horwain" *read* "Hirwain."
,, 447, foot-note, *for* to page 39 *read* on page 471.
,, 447, line 7, *for* page 26 *read* page 467.
,, 447, ,, 8, *for* $\frac{A}{a}$ *read* $\frac{a}{A}$.
,, 448, at foot, *for* see page 39 *read* see page 471.

NOTE.—Owing to the alteration of the pagination in reprinting, to correspond with that of the GEOLOGICAL MAGAZINE, some references to the foot-notes have not been altered. All the foot-notes are, however, given at end of Lecture.—A. T.

UNWIN BROTHERS, PRINTERS, LONDON AND CHILWORTH.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. II.

No. X.—OCTOBER, 1875.

ORIGINAL ARTICLES.

I.—On the Geology of Central Sumatra.[1]

By R. D. M. Verbeek,

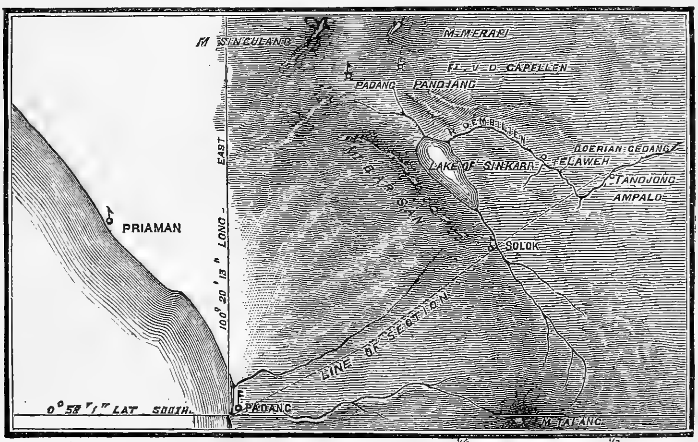
Superintendent of the Geological Survey of Sumatra.

THE fossils, which will be described hereafter by Dr. Günther, F.R.S., Prof. T. Rupert Jones, F.R.S., H. Woodward, F.R.S., and H. B. Brady, F.R.S., were found in the years 1873 and 1874, partly in rocks of the "Padangsche Bovenlanden" (Highlands of Padang), Government of the West Coast of Sumatra, and partly in marls and limestones of the Island of Nias.

In order to show the position of the fossiliferous rocks to each other, and to the plutonic and volcanic rocks which accompany them, I offer the following brief sketch of the geology of some parts of Sumatra, as far as it is known from the investigations of our Survey.

I.—*Highlands of Padang* (Government of the West Coast of Sumatra). See Map, Fig. 1, and Section, Fig. 2.

Fig. I. Map of a Portion of Central Sumatra.



Scale 1 : 1,400,000. Degrees of the Equator.

[1] This Memoir on the Geology of a part of Sumatra, including notes on Borneo and Java, by Herr R. D. M. Verbeek, Superintendent of the Geological Survey of Sumatra, is introductory to a series of palæontological papers, descriptive of Fossils from the West Coast of Sumatra, to be published with Illustrations, in the Geological Magazine, by the authority and with the assistance of the Dutch-Indian Government.—Editor.

1. The oldest rocks of this part of Sumatra are *granites, granite-syenites,* and *syenites,* in several modifications. There are granites which contain only felspar, quartz, and mica; but a great part of them contain also amphibole. The syenites contain, beside orthoclase and amphibole, almost always quartz and some mica; but the granites have more quartz than the syenites. A great part of the rocks of this group may be best called "syenite-granite," or "granite-syenite," as they stand in composition between granite and syenite. There seems to be no difference in the age of these rocks, as there are syenites which regularly pass into granites. The felspar of the granites and syenites is partly orthoclase, partly plagioclase, which shows its triclinic nature by the fine varicolored laminated structure, when examined under the microscope with polarized light. The quartz contains always a great number of "fluid-cavities."

2. Next in order follow sedimentary rocks, which are probably of either *Carboniferous* or *Permian* age, as they contain *Fusulinæ,* which are only met with in rocks belonging to the Carboniferous and Permian periods. Both Professor T. Rupert Jones and Professor H. B. Geinitz, to whom I submitted some of these fossils, determined them as *Fusulinæ*; but the Encrinital stems which occur in our Fusulina-limestone have, as Professor Geinitz informed me, a younger appearance, reminding him of the Triassic *Encrinus Cassianus,* Laube.

This oldest sedimentary formation of Sumatra can be divided into two parts. The lower portion consists of clay-slates, with auriferous quartz-veins, marl-slates, and siliceous schists; the upper part consists only of limestone, with some small beds of schists. This limestone contains the *Fusulinæ*; but these fossils also occur in some limestone beds which are found between the schists of the lower part. The schists and the limestones are conformable one with another. They are widely spread all over Sumatra, and form great mountain-ranges in the Highlands; and are often accompanied by greenstones, which will be described hereafter.

3. *Quartz-porphyries* are probably younger than the schist- and limestone-formation; some quartz-porphyries, at least, inclose fragments of schists; but it is not yet proved that *all* the quartz-porphyries of the Highlands are of the same age.

These rocks always show, when examined with the microscope, an amorphous and so-called "felsitic" matrix, which is not resolved by the highest magnifying powers into crystalline grains. In this paste are imbedded crystals and grains of quartz (with many "fluid-cavities"), crystals of felspar (orthoclase and some oligoclase), and some fragmentary, green, dichroitic crystals, which belong to amphibole.

4. *Greenstones.* These rocks, as stated above, are often associated with the older schists and limestones, which are dislocated and heaved up by them, in such a manner that portions of those rocks lie sometimes as islands upon the greenstones. The age of these rocks is not exactly known, but it is sufficiently proved that their eruption took place *before* the Tertiary Period, and that they consequently are not to be confounded with the greenstone-trachytes of Hungary. The Sumatran greenstones are pyroxenic rocks, partly diabases, partly

pyroxene-porphyries. They have a dark-coloured matrix, in which are imbedded crystals of faint-white plagioclase, green pyroxene, and magnetite. The magnetic iron-ore shows partly octahedral forms and large crystals; and it occurs copiously in excessively small grains throughout the matrix, which is coloured dark by it; and it is also found inclosed in the crystals of pyroxene. The crystals and grains of magnetite, even in the thinnest microscopical slices, are always opaque.

5. *The Tertiary deposits*, which follow next, are to be sub-divided into four groups.

a. Breccias, conglomerates, arkoses (sandstones, derived from decomposed syenite, granite, and quartz-porphyry), and *marl-slates;* the last contain remains of Fishes and Plants. This lower part of the Tertiary formation is called the *Breccia-stage*, or *Breccia-group*. The thickness differs greatly at various localities.

b. Sandstones, with clays and coals. Some Fishes and Plants. The thickness of this portion, called the Sandstone-group, varies from 300 to 500 mètres.

c. Marl-sandstones. Shells, etc. The thickness of this group is at least 500 mètres, and at some places probably much more.

d. Limestone, with Corals, Shells, etc., and abounding with *Orbitoides*. The thickness is 120 mètres.

5 *a*. The *breccias* and *conglomerates* contain fragments of the several older rocks,—syenite, granite, quartz-porphyry, Fusulina-limestone, schists, etc.

The *arkose* is a sandstone whose substances have been derived from syenite, and partly also from quartz-porphyry; the beds of coarsest grain contain balls of hard syenite; the beds of finer grain alternate with beds of the most remarkable rock of this group, namely, the marl-slate.

These marl-slates have proved to be fossiliferous at several localities on the Rivers *Sipang*,[1] *Malakoetan, Sangkaréwang, Loera Gedang*, and in the neighbourhood of the village of Telaweh; they contain Fishes and Plants. Between the marl-slates occur very thin beds of hard shale; and it is remarkable that the Fishes are always imbedded at the bottom of the marl-slates. It is thus probable that the Fishes lived in the water which deposited the shales, but that the great quantity of lime contained in the water which deposited the marl-slates was unfavourable to their existence.

The marl-slate was deposited in the neighbourhood of the old coasts as a littoral deposit, and received the land Plants from the coast.

5 *b*. The sandstones of this group are composed of quartz-grains cemented by an argillaceous paste. The colour is yellowish or brown. This is the Sumatran Coal-formation. The beds of coal vary in number and thickness at different localities; and they are generally near the base of the series. The *Oembilien Coal-field* contains about 200 millions of tons (1 ton=1000 kilograms). In the northern part of this coal-field, seven or eight coal-seams are known; in the southern portion, the so-called Soengei-Doerian Coal-field, there are only three

[1] The pronunciation of the Dutch vowels is the same as in German, except the *oe*, which is the German *ŭ*; thus the Dutch *a* is pronounced as the English *a* in *a*re, the *e* as the *e* in latt*e*r, the *é* as *a* in m*a*le, the *i* as *e* in h*e*, and the *oe* as *oo* in g*oo*d.

seams, but these are of considerable thickness. The section of this series in the neighbourhood of the village of Soengei-Doerian, from bottom to top, is:—

	Thickness in Mètres.
Sandstones and clays	50 (more or less).
First (*lowest*) *coal-seam*	6
Sandstones and clays	20
Second (*middle*) *coal-seam*	2
Carbonaceous shale, with fossil remains	½
Sandstones and clays	15
Third (*upper*) *coal-seam*	2
Sandstones and conglomerates	250 (more or less).
Total thickness of the series	350 (more or less).
Total of coal	10

The coal from the Oembilien coal-field is the best in the Netherland Colonies; and indeed, although of Tertiary age, is among the very best coals known. The composition, according to the analysis by Dr. Vlaanderen, at Batavia, is:—

$$
\begin{aligned}
C &= 76{\cdot}80\\
H &= 5{\cdot}80\\
O+(N) &= 12{\cdot}76\\
S &= 0{\cdot}45\\
H_2O &= 3{\cdot}49\\
\text{Ash} &= 0{\cdot}70\\
\hline
&\ 100{\cdot}00
\end{aligned}
$$

The theoretical evaporating power, according to this composition, A=7500.

It is a black, shining, lustrous, and compact coal. As the Soengei-Doerian seams are very regular, they are under very favourable circumstances for working.

The clays are found immediately beneath the coal-seams. The second (middle) coal-seam is covered by a carbonaceous shale, half a mètre thick, which is remarkable for its fossil remains,—spines and teeth of Fishes. The sandstones contain no fossils; the coal and the clays only a very small number of fossil Plants.

5 *c.* In the marl-sandstone series, although of considerable thickness, there are only found some small *Operculinæ* and little Fish-teeth, in the neighbourhood of the village of Moara-Bodi, and some fragments of Shells, belonging to *Ostrea, Pecten*, etc., which prove that the marl-sandstone is a salt-water deposit.

5 *d.* The upper part of the Tertiary deposits, which are known in the Sumatran Highlands, is a limestone offering a great variety of fossils,—Corals, Echinids, Gasteropods, and Conchifers, mostly as casts, and a great many specimens of an *Orbitoides*.

These four groups of strata generally succeed one another conformably, but in some localities there is a fault between 5*b* and 5*c*. The lower series, 5*a* and 5*b*, rest unconformably on the Limestone with *Fusulinæ*.

The preliminary determination of some fossils from these beds, for which I am very much indebted to Prof. T. Rupert Jones, York-town, Surrey; Prof. H. B. Geinitz, Dresden; and Prof. O. Heer, Zürich; showed that the four series or groups *5a, 5b, 5c*, and *5d*, belong to the Tertiary, and probably all to the *Eocene* period.

Among the Fishes from *5a* Prof. Geinitz determined *Fistularia Kœnigi*, Agass., which occurs in the Eocene schists of Glarus (Switzerland); some other Fishes strongly resemble *Osmeroides* (subgen. *Sardinoides*, v. d. Marck) *microcephalus*, Münst., and *Osm.* (*Sard.*) *Monasterii*, from the "Plattenkalke" of Sendenhorst, Westphalia, which are of Senonian age (described and figured by v. d. Marck in "Palæontographica," vol. xi. pl. 6, and Agassiz, "Poissons fossiles," vol. v. pl. 60*d*).

The fossil Plants from *5a* have a more Miocene than Eocene character. Some have already been described and figured by Prof. O. Heer in the "Abhandlungen der schweizerischen paläontologischen Gesellschaft," vol. i. 1874. According to Prof. Geinitz, there are some Echinids from *5d* nearly related to *Prenaster Alpinus*, Desor (Desor, "Synopsis des Echinides fossiles," 1858, p. 401, and W. A. Ooster, "Petrifications remarquables des Alpes Suisses; les Echinodermes," p. 112), and to *Periaster subglobosus*, Desor (*op. cit.* p. 385) and W. A. Ooster (*op. cit.* p. 109), both from Eocene or Nummulitic rocks of Switzerland. It is therefore highly probable that *5d* belongs to the Eocene period. As *5d* is the *upper* part of all these sedimentary deposits, the formations *5c*, *5b*, *5a*, must be of Eocene age too. It is not at all probable that *5a* belongs to the Upper Cretaceous (Senonian) formation, firstly, because the Senonian character of *some* Fishes from *5a* is easily explained, the Marl-slates being the *oldest* of all our Eocene deposits, and the fossils from the Senonian "Plattenkalke" of Sendenhorst, although older, having a strong resemblance to those from Eocene rocks of other parts of Europe; secondly, because rocks of Cretaceous age are wanting in the Highlands of Sumatra; thirdly, because the Marl-slates at the top of the series become sandy, and pass into the coal-bearing sandstones of *5b*, which are most probably of Tertiary age; fourthly, because the fossil Plants from *5a* have a Tertiary, and even more of a Miocene than Eocene, character.

The Eocene formation of Sumatra is thus represented in four groups, or *étages*. That of Borneo, according to my investigations, is only represented in three groups. The lowest of these latter contains the coals; the middle part consists of marls, with some few Nummulites (*Nummulina Pengaronensis*, Verb.) and many specimens of *Orbitoides discus*, Rütim.); the upper part is a nummulitic limestone with millions of Nummulites and some Orbitoides.

Perhaps the coal-bearing sandstones of Borneo are the equivalent of the Sumatran coal-bearing formation *5b*; the Borneo marls, the equivalent of the marl-sandstones *5c*; and the nummulitic limestone of Borneo may be the equivalent of the limestone with Orbitoides *5d*; in which case the equivalent of the marl-slates with Fishes would be wanting in Borneo. But as there is a very great difference between the Eocene fossils from Borneo and those from Sumatra, this can only be proved by a careful comparison of the fossils. Those which I gathered at Borneo will soon be described by Dr. O. Böttger, Frankfort-on-the-Maine; Dr. von Fritzsch, Halle; and Dr. Geyler, Frankfort-on-the-Maine; and the memoirs will appear in the "Palæontographica." (See two memoirs of mine, on the geology of the South-eastern part of Borneo, in the "Jaarboek voor het Mynwezen in Nederlandsch Oost-Indië," Amsterdam, 1874 and 1875. I have formerly described the Nummulites of the Borneo limestone in the "Neues Jahrbuch für Mineralogie, etc., 1871, pages 1–14, pl. i. ii. iii.)

The coal-bearing sandstones of the south coast of Bantam, in Java (not those in the interior of Bantam, which are younger), according to Mr. F. Junghuhn's description (Junghuhn's "Java," etc., German translation, Leipzig, 1852, part iii. pages 163-179), are covered first by marl-stones and clays, and next by limestone, which contains Nummulites more to the east, on the River Kaso (Junghuhn, "Java," part iii. pages 64, 87, and 203); and Prof. von Hochstetter confirms the occurrence of these fossils in the limestone to which the cavern of Linggo-Manik belongs ("Novara-Reise; Geologie," ii. page 146).

It seems to me highly probable that these three series of rocks of Java are the equivalent of the rocks of Borneo described above; and that thus the coals of Java and Borneo, and perhaps those of Sumatra too, belong to the same part of the Eocene period. In order to avoid errors, I must state here that in several parts of the Archipelago coal-beds are also found in rocks which are younger than Eocene; but these coals belong to the brown coal, and are always much inferior in quality to the black Eocene coals. These brown coals are found, 1. in the interior of Bantam (Java), in the neighbourhood of the village of Bodjong-Manik; 2. in the neighbourhood of Doesson-Caroe, in Laïs and Kataoen (Benkoelen, Sumatra), and Palembang (Sumatra); and 3. in the marls of the Island of Nias.

6. The *Trachytic rocks* of Sumatra are all younger than the Eocene period; they are of middle and late Tertiary age (Miocene and Pliocene); and it seems that this is the case in Borneo and Java also.

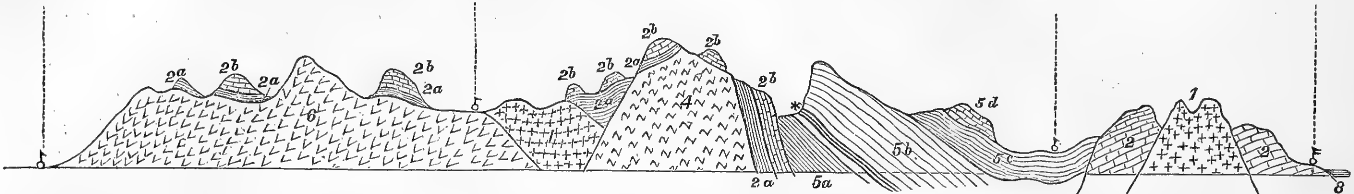
There are two different groups of trachytic rocks; the one, probably the older of the two, composes mountains and mountain-ranges, without craters, and having no connexion with volcanos; the other comprises the trachytic rocks belonging to the volcanos, those giants of Sumatra and Java, which are often more than 10,000 feet high.

The trachytes of the first class, found in Sumatra in the immediate neighbourhood of Padang and Sibogha, and at several other localities, are oligoclase-trachytes, the so-called *andesites* (Zirkel); they contain no sanidine, but exclusively a triclinic felspar, either with amphibole (and now and then some quartz and mica), or with pyroxene.

These andesites are widely distributed in the south-east part of Borneo, where they have dislocated the coal-bearing rocks; they are known too in Java.

The rocks composing the volcanos of Sumatra are of various kinds; there are andesites, trachytes with sanidine and oligoclase, trachyte-pitchstones (Trachytpechsteine, with sanidine and without oligoclase), obsidians, and pumice-stones. The volcanos of the Highlands of Padang are named:—the Talang, the Singalang, the Merapi, the Sago, and the Ophir. The Singalang and the Merapi are about

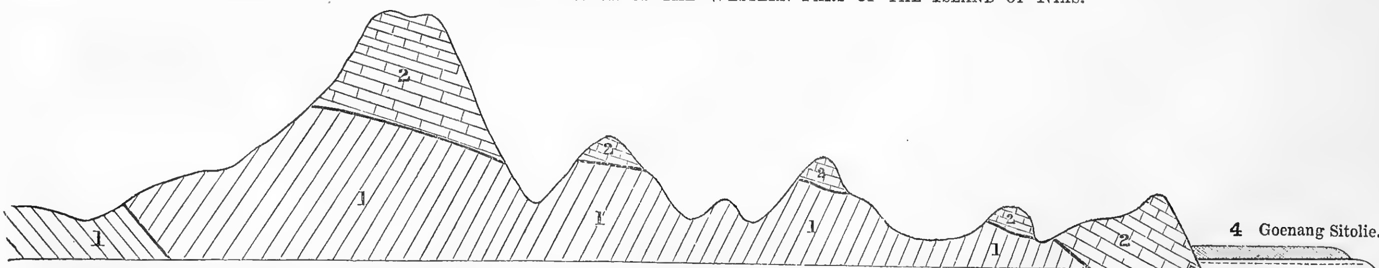
FIG. II. DIAGRAMMATIC SECTION OF SUMATRA FROM PADANG TO DOERIAN GEDANG.



1. Granite, Syenite, etc.
2a. Clay-slates, Siliceous Schists. } Older Sedimentary
2b. Limestone with Fusulinæ. } formations.
3. Quartz-porphyry (not represented in the section).
4. Diabase and Pyroxene-porphyry.

Younger sedimentary formation. *Eocene.*
5a. *Breccia Group*, Breccias, Sandstones, Marl-slates, with Fishes and Plants.
5b. *Sandstone Group*, Sandstones with Coals (*) and carbonaceous shale with Fish Teeth.
5c. *Marl-sandstone Group*, Marl-sandstones, and Clay-sandstones with Operculinæ and [some small Fish Teeth.
5d. *Coralline Limestone* with Orbitoides.
6. Andesites and Trachytes.
(7. Diluvium, not represented in the Section.)
8. Alluvium.

FIG. III. DIAGRAMMATIC SECTION OF THE WESTERN PART OF THE ISLAND OF NIAS.



1. Marls, Marl-sandstones and Clay-sandstones (probably of Miocene age).
2. Coralline Limestones, with Small Nummulinæ (Pliocene?).
3. Coral Banks. } Recent.
4. Sea Sand. }

10,000 feet high; the others are lower, but all the volcanos of Sumatra surpass 6000 feet. The volcanos of Java are described by Mr. Junghuhn in his above-mentioned work.

Borneo contains no volcanos. The mountain Kina-Baloe, in the northern part of Borneo, which was formerly supposed to be a volcano, is composed of a granitic rock.

There are two lakes in the Highlands of Padang which owe their origin to infallings of volcanic ground on a very large scale.

The greatest length of the Lake Singkorah is 21,000 mètres, the greatest breadth 7700, the smallest breadth 3350, and the circumference 53,000; the surface is 2·04 square geographical miles. The only channel which carries off the water of this lake is the Oembilien River, which is afterwards called Kwanten, and finally Indragiri, and has its mouth on the east coast of Sumatra. The Lake Manindjoe is 16,600 mètres in length, the greatest breadth is 8000, the least breadth 3650 mètres; the circumference is 48,900 mètres, and the surface 1·81 square geographical miles (1 geogr. mile=$^1/_{15}°$ of the Equator). The water of this lake is carried off by the Antokkan River, which has its mouth not far from Tikoe on the west coast.

The surface of these two lakes is, in comparison with other lakes in volcanic districts, as for example the "Maare" of the Eifel, very considerable. The surface of the Lake Singkorah is 33 times, and that of the Lake Manindjoe 29 times greater than that of the Lake of Laach (Laacher See) in the Eifel.

7. The *Diluvium* of the Highlands of Padang is a river-deposit; and is chiefly composed of tufaceous conglomerates and sandstones. The beds are always horizontal, and contain many fragments of trachytes. These are two characters by which the Diluvial conglomerates are easily separated from the conglomerates of Eocene age. The Diluvial beds form river-terraces, which attain a height of twenty to thirty mètres above the alluvial deposits.

8. The *Alluvial* river-deposits are for the greater part transformed into rice-fields (sawahs).

In the Section Fig. 2, the western part of Sumatra is represented from Padang, on the west coast, to the village of Doerian-Gedang, near the frontier of the independent districts. The eastern part of Sumatra, from Doerian-Gedang to the east coast, is not given in the Section, as that part is composed only of recent deposits of the Rivers Djambi, Indragiri, and Kampar. With the exception of the quartz-porphyry (3) and the diluvium (7), all the above-described rocks are represented in the Section. The four groups of Eocene deposits are generally conformable with each other, but unconformable to the old Fusulina-limestone; but, as was stated above, in some localities there is a fault between *5b* and *5c*.

II.—*The Island of Nias* (Government of the West Coast of Sumatra). See Fig. 3.

This island is situated westward of Sumatra; its surface is about 70 square geographical miles. It is chiefly composed of marls, clay-marls, clays, and very fine-grained sandstones, partly of tufaceous nature. It is most probable that the materials of the greater part of these rocks were derived from volcanic rocks, but on the Island of Nias itself no such rocks occur.

The beds of marls, clays, etc., are very much dislocated, and vary much in direction and in dip; they are seldom horizontal. They have a bluish-grey colour; and are probably of Miocene age, according to Dr. O. Böttger, to whom I submitted some of the fossil Conchifers and Gasteropods from these marls.

In the neighbourhood of Goenoeng-Sitolie, the chief place of the island, and also at some other localities, the marls are covered by an unconformable limestone.

It is remarkable that this limestone, probably (from its discordant position) of late Tertiary age (Pliocene?), contains, besides indistinct fragments of Corals, some small *Nummulinæ*. It is a new proof that this genus not only occurs in rocks of Eocene age, but in younger rocks too. The diameter of the *Nummulinæ* from the Nias limestone is three millimètres, the thickness 1 to $1\frac{1}{4}$ millim.; they have eight whorls, about 150 chambers, the central chamber is small; their internal structure resembles very much that of the Eocene, *N. Pengaronensis*, Verb., from Borneo, and perhaps they are a small variety of that Nummulite.

The position of the different rocks in the neighbourhood of Goeneng-Sitolie is shown in the Section Fig. 3.

For those who feel interest in the Geology of Sumatra, I add a list of the principal geological papers on parts of that Island.

1. *F. Valentijn.* Oud en Nieuw Oost-Indiën, 1724. Sumatra, in vol. v.
2. *William Marsden.* History of Sumatra, 3rd edition. London, 1811.
3. *Malayan Miscellanies;* published at the Sumatran Mission Press, at Bencoolen: vol. ii. (1822) contains accounts of several journeys.
4. *Dr. Jack.* On the Geology of Sumatra. Transactions of the Geol. Society, new series, vol. i. page 397.
5. Memoir of the Life and Public Services of *Sir Thomas Stamford Raffles.* By his Widow. London, 1830. Particularly in the Government of Java, 1811–1816, and of Bencoolen and its dependencies, 1817–1824.
6. *L. Horner.* De Batoe-eilanden. Tijdschrift voor Nederlandsch Indië. Jaargang iii. vol. i. p. 313-371.
7. *L. Horner.* Reizen over Sumatra. Tijdschrift van het Bataviaansch Genootschap, vol. x. pp. 322-373.
8. *S. Müller.* Gezigten van bergen, kraters, kusten en eilanden van Java, Sumatra en straat Sunda. Verhandelingen over de natuurlijke geschiedenis der nederlandsche overzeesche bezittingen, door de leden der Natuurkundige Commissie. Leyden, 1839–1844, pp. 447–469 (with plates).
9. *F. Junghuhn.* Die Battaländer auf Sumatra. Berlin, 1847, 2 vols.
10. *F. Junghuhn.* Java (German translation, Leipzig, 1852), vol. i. pp. 51, 70–72, 75–78, 99–106, with seven sections (topography of Sumatra); vol. ii. pp. 808–816 (volcanos of Sumatra).
11. *Nieuwenhuizen en v. Rosenberg.* Verslag omtrent het eiland Nias. Verhandelingen van het Bataviaansch Genootschap, vol. xxx. 1863, pp. 1–153.
12. *W. H. de Greve.* Het Oembilienkolenveld in de Padangsche Bovenlanden. 's Gravenhage, 1871.
13. *R. D. M. Verbeek.* In the "Jaarboek voor het Mijnwezen in Nederlandsch Oost-Indië," vol. iii. and iv. 1874 and 1875, the following momoirs:
    a. Preliminary report on the Island of Nias.

b. On the age of the Oembilien Coal-field.
c. Geological description of the Oembilien Coal-field.
d. On the Geology of the Island of Nias, with several maps and sections.

Fort van der Capellan, West Coast of Sumatra,
March 10th, 1875.

II.—On the Origin of Coums.

By J. G. Goodchild, F.G.S., of H.M. Geological Survey.

In my paper on Glacial Erosion lately laid before the readers of the Geol. Mag. (pp. 323 and 356), I have endeavoured to prove that the origin of nearly all the more prominent surface characteristics of the rock scenery in the Yorkshire Dale District admits of a simple and complete explanation by the theory of the modification of pre-existing subaerially eroded surfaces by Glacial Erosion. At the same time it was shown that the character of many of the phenomena is entirely opposed to any theory of their origin by means of Subaerial Denudation alone. In the present communication it is proposed to inquire how far this Glacial Erosion theory may be applied to explain the origin of the deep, semicircular recesses that are commonly found in all well-glaciated mountainous districts, and are variously known by the names of Coums, Corries, or Cirques.

The more prominent terraces and scars whose origin was discussed in the paper just referred to seem to occur only where the ice moved in the direction of the valley's length: where the ice flowed to a greater or less degree across the valley, or, in other words, where the ice moved across, instead of along, the outcrops of the beds, these characteristic scars and terraces are either slightly developed, or else are wanting altogether. But whatever the minor inequalities of the slopes of the valleys may be like, it is commonly found that there is a striking resemblance in form between the contours of the surface at any given elevation and the contours for a considerable distance both above and below. Where the side of the valley is convex in contour, the gradations in form are complete between the curves of largest radius near the bottom of the valley, and the more decidedly rounded contours of lesser radius that are found in greatest perfection at the higher parts of the feature. So, too, with the slopes that present concave contours. In these the least regular curves are nearly always found near the base, and the contours gradually become more decidedly concave and of larger radius as the upper limits of the feature are approached; and, as a rule, it is also at the upper limit that the most regular curves occur.

Some of the rock surfaces whose form I have before endeavoured to show must be due to the unequal resistance to mechanical erosion offered by beds of various degrees of hardness graduate, by insensible degrees of form, from surfaces with contours that are nearly straight, through others that are more or less concave, into semicircular recesses that remind one rather of gigantic pot-holes than of anything else. A very beautiful example of this kind occurs at the head of Snaizholme Beck, about a mile to the south of Hawes, in Wensleydale. Others of similar but less perfect form may be found in the neighbourhood.

In all such instances that have hitherto come under my notice, both in the Dale District and elsewhere, there are certain points of resemblance common to all. In their lower parts, many, perhaps nearly all, hardly differ in any noticeable respect from the steeply sloping head of an ordinary valley, except that they are, perhaps, of somewhat greater width. The bottom of the hollow is almost invariably occupied by a stream, of which a part is often so much enlarged as to form a tarn, and in a few cases the tarn can be shown to lie in a true rock basin. Looking upwards at the higher parts of the coum from the position of the tarn, one cannot fail to be struck with the sweeping outline of the walls of the amphitheatre as these are seen against the sky. In many instances the curve is so regular, and so little interrupted by stream courses, that it seems rather as if the shape had been produced by artificial means than by purely natural causes. Viewed from the sides, at a higher elevation, the regularity of the curvature is quite as obvious. From such a point, too, one can see how markedly the valley-like form of the amphitheatre's lower part contrasts with the sweeping curves of the parts nearer the top, and how gradually the contours change in form from one extreme to the other. Above the line where the greatest regularity of form is observable the coum frequently terminates somewhat abruptly among rock features that do not present any striking or unusual peculiarities. In nearly all cases it is abundantly manifest about all such amphitheatric recesses that they are slowly, but surely, losing their regularity of form and smoothness of outline. Wherever a spring bursts forth, the continuity of the curves is more or less interrupted, and the slopes below are encumbered with the rock that has been thus undermined; and the gully formed by any stream that flows downwards from the edge of the coum is quite unlike any part of the smooth, concave surface of the other parts. That very little denudation has taken place in Post-Glacial times in these cauldron-like hollows is evidenced by the presence, high up on the sides of the hollows, of glacial drift that in a few cases can be shown to date from the last ice-sheet period; moreover, glacial striæ are found in a few instances in such a position and with such directions that it is plainly impossible that the form of the surface can have undergone any important modification since it was left by the great ice-sheet—a view that is further borne out by the general freedom of the drift surface from fallen rock fragments from above. Indeed, in a few instances it would seem as if so much of the old weathered part of the rock was removed by the ice-sheet that subaerial forces have only just begun to produce any noticeable effect upon the sweeping outlines of the surface. It may be true that in the case of many coums these remarks do not apply; but if they can be shown to be true of one only, it proves that in that particular instance the peculiarities of surface configuration have been produced by other agencies than those now at work upon the surface.

Several theories have, at different times, been advanced to account for the origin of these singular crater-shaped hollows; but hitherto no thoroughly satisfactory explanation has been given. Where they occur in rocks of tolerably uniform lithological character throughout great thicknesses of strata, there does not seem to be much difficulty in accepting the theory that attributes their origin to the combined action of springs and meteoric agencies. But where, as in the Lower Carboniferous rocks of the north-west of England, we find them just as perfect in form in a series of rapid alternations of horizontal strata that have very different rates of destructibility under any kind of disintegrating influence, many difficulties arise which plainly show that this theory is untenable. In the paper referred to at the head of this communication it has been shown that, under purely subaerial influences, the form of the surface that would be developed out of any such series of rocks as those in the Dale District would be in many respects different from what we actually find.

Just to take one objection—all the springs in the Dale District tend more or less to break out along certain definite lines, most frequently between a limestone and the less pervious grit or sandstone that it lies upon. Hence, the tendency of springs, as they act rather by undermining than by actual erosion, would be in nearly all cases to cut back the beds above that whereby the spring is thrown out. As a result, the lower bed would soon be left as a shelf projecting beyond the outcrop of the next bed above; unless there happen to be springs below which undermine the impervious bed at the same rate as that maintained by the higher springs. Even in that case the result would soon take the form of a gully or ravine, in no way different from an ordinary bed of a stream; and it is obvious that unless springs were acting simultaneously over the whole surface—or, what amounts to the same thing, unless the springs are continually changing their point of outburst so that the whole rock surface is uniformly acted upon—the result must inevitably present a jagged and irregular contour at all elevations; which is a form of surface totally unlike almost any unmodified part of a single coum that I have ever seen. Again, the objections brought forward against the subaerial origin of the straight lines of scar in the Dale District apply equally well in these cases; because it frequently happens that the more prominent rock features in the coums consist of the kinds of rock that, under subaerial influences, tend to disappear with the greatest rapidity, while, at the same time, they are the rocks that are best capable of withstanding erosion by mechanical means. Besides these objections there are others that are set forth in the paper on Glacial Erosion. But even if these objections did not suffice to show the untenability of the Spring Theory, the existence of such one-sided pot-hole-like hollows in rocks of very different lithological character and lying at every imaginable angle seems to shake one's faith in any of the theories that have yet been proposed to account for their origin. In the case alluded to, which is along the Cross Fell Escarpment between Melmerby and Ousby, in Cumberland, the rocks forming the coum consist of highly inclined and contorted Lower Silurian; thick masses of vertical and highly inclined Carboniferous conglomerates belonging to the Calciferous Sandstone Series; and variously inclined beds of Lower Carboniferous rocks of the ordinary Dale District type. Yet the general regularity of form and the uniformity of curvature of the crater-like recess that all the rocks have been ground into is particularly striking when one is aware of the nature and the lie of the rocks that form the walls of the amphitheatre. This instance is one of many others in the neighbourhood, all of which are remarkable for their sweeping outlines and general regularity of form.

In regard to the position of these coums no very general rule can be laid down. They seem, however, to occur with greatest frequency in the neighbourhood of the highest ground, especially where there is much diversity in the directions taken by the larger valleys. Not a few coums occur at the heads of valleys, of which the Snaizholme Coum may be taken as a very good type. They are, however, by no means confined to such situations, but occur almost as commonly on the sides of valleys, far removed from the source of the stream. In a few instances such recesses are found in considerable perfection on the sides of a main valley opposite the point where this is joined by a tributary of considerable size. Good examples of such are to be found in the Coum wherein Bolton Castle in Wensleydale stands, just opposite where the Yore valley is joined by the large branch dales of Waldendale and Bishopsdale; at Bampton near Shap, where the valley of the Lowther is joined by the Hawes Water valley; and again at Lowther Park, where Heltondale and the Lowther valley join. Many similar cases to these might easily be pointed out if there were further need to do so. In some of these instances the most regularly curved outlines are found only within a small vertical extent of the hollow where they occur; in other instances the curvature is so slight that, on the ground, it seems almost imperceptible; but a reference to the beautiful one-inch maps of the Ordnance Survey shows that these seemingly unimportant curves are in reality but parts of curved surfaces of much greater extent, whose real nature can only be seen by looking at them from a considerable distance, from which point the curve is often seen to inclose an arc of sixty, eighty, or even a greater number of degrees. The three coums referred to above are shaped out of a series of alternations of hard beds with others comparatively soft in regard to their capacity to resist mechanical erosion, and the rocks they occur in are more or less inclined from the horizontal; yet the resulting terraces in each case are equally well developed at one point as at another. In the case of the Lowther recesses the rocks and their terraced outcrops incline inwards towards the high ground; yet, although there is in this instance a combination of circumstances most favourable for the retention of rock debris detached by subaerial agencies, hardly a fragment of any of the harder rocks is to be found loose at the surface, which seems as if it had been swept clean from one end to the other; except where a thin coating of drift has been left by the melting of the ice-sheet.

Similar remarks apply also in part to many other such recesses in like positions.

Now, as an ordinary glacier scoops, necessarily, only in a downward and outward direction, we ought to find, if the theory of the origin of coums by means of glaciers were the true theory, that all traces of horizontal prominences have been ground off by the ice; and, in place of terraces extending at right angles to the path the ice must have taken, we ought to find whatever furrows the ice left, in, or nearly in, the line of motion of each part of the bottom of the glacier. Yet, it is a well-known fact that where the rocks that form the coum consist of a nearly horizontal set of alternations of beds of different degrees of hardness, each separate hard bed forms an amphitheatric shelf or terrace, which is separated from those above and below it by a horizontal interval, often of considerable extent; so that the general effect resembles, on a gigantic scale, the tiers of seats in a great amphitheatre. This is especially noticeable in the case of many of the cirques in the Jura, some instances of which have been mentioned by the Rev. T. G. Bonney in his paper on the origin of Cirques. It is clearly impossible that any such ledges of rock can be due to the erosive power of ice acting vertically; and therefore, as very perfect coums exist to which the theory of glacier erosion will clearly not apply, we are forced to conclude with Mr. Bonney that simple *glaciers* have had little, if they have had anything, to do with the formation of the greater number of the coums, either here, or on the Continent.

There are some other and perhaps not less weighty objections against the glacier origin of coums. It has been before remarked that the greatest regularity of form is often to be found only near the higher parts of the recess; while, in their lower parts, many of the coums do not differ very much from the higher parts of ordinary valleys, except that in a few cases they are flatter, or rather wider than one usually finds the head of a similar valley where no coum exists; and that rock basins on a small scale often occur at the foot of the steeper slopes. It seems quite clear that if the coums are due to the scooping out of a valley head by the long-continued action of a small glacier, the greatest amount of erosive force must have been exerted in those parts of the coum that had the greatest overburden of ice—in the higher parts, where the neve was hardly sufficiently consolidated to deserve the name of ice at all, the amount of erosive force exerted must be very small indeed. Yet the lower parts are those that, in many instances, do not differ very much from ordinary valley heads; while at the higher parts, where the glacier ice can have exerted little or no erosive power, the configuration of the surface plainly shows that the erosive agents have acted with the greatest effect. Again, where tiers of rock ledges occur one behind another, as they do in some of the English coums, and more strikingly in those of Switzerland, it is also obvious that the coums cannot be due to the undermining of the higher rocks by a glacier that was grinding away the soft beds at the lower part of the recess. Such action, where the rock is of a uniform lithological character, might give rise to a rudely semicircular hollow with steep craggy walls; but it is quite impossible that this, or any other *vertically* acting force could ever give rise to tiers of rock shelves with the unbroken sweeping curves that actually occur. Lastly, many, perhaps the greater number of coums occur in such situations that, if they had ever been tenanted by a glacier, this, in consequence of the nearness of the hollow to the snow-shedding line, must rarely have exerted much pressure upon its bed; even supposing that, in such a situation, the neve was sufficiently consolidated to take on the properties of ice in any form. If, then, perfect coums exist where, under glacier conditions, there could hardly have been sufficient pressure to consolidate the neve in the bottom of the coum into ice, much less near its upper margin, it seems clearly impossible that an ordinary glacier, or, indeed, ice in any form moving in the way that a glacier does, could give rise to the crater-like recesses whose origin is here discussed.

The widely different elevations that adjoining coums are found at, and the entire absence of any marks of erosion in their neighbourhood that can clearly be shown to be the work of the sea, are objections of sufficient weight to convince most field geologists that very few indeed of these pot-hole-like hollows have received their present form by marine action.

All who have followed Professor Ramsay in collecting facts relating to Glacial Erosion have remarked upon the association of well-glaciated rock surfaces with coums and rock basins; and, probably, they have all felt more or less convinced that this association is something more than accidental. The close resemblance of many of the coums to gigantic pot-holes, such as, on a small scale, a mountain torrent drills in its bed, seems to point to some analogy in their modes of formation; and this view is considerably strengthened when it is found that the position of not a few of the coums bears the same relation to the direction, position, and relative sizes of the adjoining valleys that the position of their smaller analogues do with regard to the direction, position, and relative sizes of the rock channels that cause the eddies in a river.

In the paper on Glacial Erosion an attempt has been made to prove that all the minor features of the scenery in the north-western part of the Dale District are due to mechanical erosion by land ice, which in all probability rose to a level of at least 2400 feet above the sea, and may have had a greater thickness even than that. It was pointed out that the erosive powers had acted unequally upon the beds in proportion to their relative powers of resistance to *mechanical* erosion; and also that in some cases it is almost certain that a considerable thickness of rock must have been removed by the ice in this way. The eroding agent followed the pre-glacial configuration of the surface, removing much of the weathered part of the rock, and replacing the notched and irregular weathered surface, and the talus-covered slopes, by unbroken and sweeping lines of scar, terraces of unweathered rock, and slopes coated with little other superficial accumulations than the drift matter that had once been dispersed throughout the entire thickness of the ice-sheet over that particular spot.

Those who have read the paper thoughtfully will at least admit that if the ice-sheet really accomplished as much denudation as is therein claimed as its work, the very nature of the agent would lead us to expect results different in many important respects from those accomplished by purely subaerial means. Unlike a river, which can transport the rocky material it has removed only along some part or other of its bed, much of the debris detached from the old pre-glacially weathered and shattered rock surface by the ice that was slowly moving over it gradually worked its way into the body of the ice; where, being practically unaffected by the force of gravity, it quietly floated away in the higher and swifter flowing strata of the ice, towards the outer margin of the ice-sheet, leaving comparatively little detritus between the sole of the ice-sheet and the rock surface. A little consideration will convince any one that an agent acting in this manner would erode as freely at an elevation lower than the rock surface a little further down the valley—in other words, in a rock basin—as at any other part of its bed; because, as fast as the detritus was removed from the rock, it tended more or less to work upwards into the body of the ice, where the more quickly flowing strata would soon remove it seawards. In the case of a river the force of gravity comes more strongly into play, so that, except in a pot-hole, when once a large stone gets much below the general level of the bed of the river, there it must lie, until some accident brings it again to the level of the river's bed.

Mr. Croll's theory of the "Physical Cause of the Motion of Glaciers," published in the Phil. Mag. for March, 1869, enables us to understand how ice, whilst possessing many of the properties of a fluid, may yet at the same time behave in many respects as a semi-solid. A proper appreciation of Mr. Croll's theory; of the theory put forward in the first instance by J. D. Forbes, and since extended by Mr. James Geikie, on the up-travelling of boulders;[1] and of the actual thickness that it can easily be shown that the ice really had; is, I think, all that is necessary to convince the most sceptical that the theory of the origin of rock basins by glacial erosion is the only theory that really accords with the facts. In all probability the greatly diminished rate of flow of the lower strata of the ice as compared with the flow of the strata near the surface, is quite compensated, so far as the erosive power of the ice is concerned, by the enormously increased pressure. Hence it is far from unlikely that the actual amount of erosion accomplished by the bottom ice may not be far short of, if it does not equal, or even exceed, the amount of erosion effected by the comparatively swift-flowing ice of the higher parts of a glacier's sides.

In order to rightly understand the theory that I have elsewhere given[2] to account for the origin of coums, it will be well to summarize a little of the evidence relating to the behaviour of a thick mass of land ice in motion that can be gathered from the sources at

[1] On the Occurrence of Erratics at Higher Levels than the Rock Masses from which they have been derived, Trans. Geol. Soc. Glasgow, vol. iv. pt. 3, p. 235.

[2] Quart. Journ. Geol. Soc. for Feb. 1875 (read 24th June, 1874).

present open to us. As, in the present state of science, we have no means of discovering what is actually taking place in and beneath the ice of a great continental mass like that of the ice-sheet of Greenland, we are compelled to rely upon the data supplied by the glaciated rock surfaces left by the ice of the European Ice-sheet Period, and to supplement these by the data, less satisfactory in some respects, that are afforded by the puny descendants of the Ice-sheet of Mid and Northern Europe. Even in the Arctic regions we should hardly expect to meet with ice in a state precisely similar to what obtained during the Ice-sheet Period in England. Wherever perennial ice has lingered from the Glacial Period to the present day, the erosion of the old weathered surface by the ice must be greater in proportion to the length of time that has elapsed since the last traces of the Ice-sheet left these parts. When the Ice-sheet left the North of England, it is highly probable that there was much weathered rock left to furnish the materials for more drift; but in the glacier regions of the present day the ice has accomplished much more, and there is probably little else than perfectly sound rock left for the ice to erode.

When we examine any large extent of nearly flat glaciated surface lying near the bottom of a deep valley, we usually find that most of the striæ run for considerable distances without any great deviation and without interruption, and that the larger grooves, even those of an inch or more in width, are ploughed out in lines paralled to those of the finer scratches around. As a rule, these larger grooves bear no necessary relation to any structural planes in the rock, and they bear every appearance of having been produced at one operation by the steady grinding of the rock by the slow onward movement of the sole of the Ice-sheet armed with bigger stones than those that produced the adjacent finer scratches. As scratches of this character occur along the whole length of the bottoms of valleys, right up to the source, we need no other evidence to convince us that the very lowest strata of the old glaciers were impelled forward as well as the higher strata were; and that, even at a considerable depth from the surface, grooves of large size could be made at one operation, although the absolute rate of flow of the sole of the Ice-sheet may have been so slow as to be almost imperceptible if it could have been tried by any of our most carefully constructed modern instruments. When it is remembered that a sheet of ice "1000 feet in thickness has a pressure on its rocky bed equal to about 25 tons on the square foot,"[1] and that the actual thickness of the ice in the Yorkshire Dale District equalled, and in places exceeded 1500 feet, the amount of erosion accomplished during the whole of the Glacial Period may have been something considerable. It is a very noteworthy point that where a large branch valley joins the main valley, the main valley striæ are more or less deflected from their general parallelism with the larger contours of the part where they occur; and, what is of still greater impor-

[1] J. Croll, On Geological Time and the Probable Date of the Glacial and the Upper Miocene Period, Phil. Mag. Nov. 1868.

tance, Mr. Ward has lately pointed out before the Geological Society that in some of the Cumberland Lake Basins the lines of greatest depth are deflected in the same manner off the mouth of a great branch valley to such an extent that they run well in towards the shore of the lake opposite the mouth of the tributary. Turning to the facts obtained from a study of the behaviour of the Swiss glaciers, we find that where two glaciers unite at a considerable angle, the surface moraines of the more powerfully flowing glacier are impelled right across the path of the smaller glacier, in a few instances nearly to the opposite bank. Besides this, where the valley that a glacier flows in has many bends, the line of swiftest motion crosses the centre line of the glacier at each point of contrary flexure, exactly as the line of swiftest flow of a river does under similar circumstances.

Taking these facts into consideration, it will be seen that, independently of any theory whatever, we can feel a tolerable amount of certainty that force can be transmitted horizontally for considerable distances through ice; and the facts obtained from the glaciated surfaces seem to prove that force can be transmitted a considerable distance through ice, not only in a horizontal direction, but also to some extent in a direction approaching the vertical. It seems otherwise impossible to explain the occurrence of the phenomena referred to above except on a supposition of this kind. Those who accept Mr. Croll's theory of glacier motion will at once perceive that these results are precisely such as might have been expected.

In regard to the quantity of rock removed in this way by the ice from the bottoms of the valleys, we have as yet no trustworthy evidence; but there is every reason for believing that the quantity of rock ground away from the lower parts of the valley's sides was something considerable, hence it may be safely inferred that the valleys were also deepened in the same proportion. To repeat what was stated above—the ice certainly removed all traces of the pre-glacially weathered part of the rock from the lower ground, and in doing so, while in the main it followed the configuration of the surface left by subaerial agencies in pre-glacial times, it carved the rock surface into forms different in many respects from those resulting from subaerial action alone, and bearing characteristics such as can be impressed by the agency only of land ice in motion.

If, then, there is no alternative but to refer the origin of the straight lines of scar in the Yorkshire Dale District to glacial erosion, it seems to follow that all the accompanying forms of the surface that they are associated with, and that they pass into by insensible gradations of form, must have originated in the same manner. If the slightly concave surfaces of the valley sides are due to the slow grinding of the stone-shod ice-sheet moving horizontally in a slightly curvilinear direction through long periods of time, the more deeply concave recesses that they graduated into, and that occur with them, have assuredly originated in the same way. The only difference in the two extreme cases would be, that in the case of the shallower coum local circumstances did not tend to deflect the ice much out of its normal direction; in the other, local circumstances, which in many cases may have remained constant throughout the whole period of the Ice-sheet, caused the ice to move in a direction more decidedly curvilinear, so that in the end the rock surface was ground into its present form.

If it be conceded that force can be transmitted considerable distances in any direction through ice, the analogy of a glacier with a river is complete in nearly every respect. We may, therefore, venture to speculate upon the existence in the great ice-sheet of phenomena parallel to any that are known to occur in rivers. If we examine a shallow river about the point where it is joined by a tributary of considerable size, we usually find that the shingle on the bank of the larger stream opposite the point where it is joined by its affluent is swept away by the conjoined currents, so as to leave a kind of bay with a regularly curved outline, which varies in form and position with the relative directions and intensities of the two currents to whose joint action the deflection of the stream is due. Compare this with what occurs on a larger scale in rock masses: where the larger ice-filled valleys were joined by powerful tributaries, the bank opposite the point of junction is ground into a bay of exactly the same form as that swept out of the shingle by rivers of the same relative volumes under like circumstances. The stone-shod ice of the main stream was impelled by that of the tributary against the bank opposite the point of confluence, and the combined effect of the two currents caused the ice to move in a more or less curvilinear direction, until it gradually merged into the direction of the main valley, a long way farther down the stream. The Bolton Castle Coum is an excellent instance of this kind. The ice of the main valley, throughout perhaps the greater part of the ice-sheet period, was kept pressed against its north bank by the two powerful tributaries that came down Waldendale and Bishopsdale, whereby the conjoined streams were compelled to move slowly in a curve until they flowed again into the normal direction farther down Wensleydale. As the conditions that gave rise to the curvilinear motion remained constant throughout the whole of the glacial period, while the ice maintained not less than a certain thickness, it is quite possible that the result may be due, in this case, as in many others, to the long-continued action of comparatively feebly acting causes bringing about results that seem at first sight to require more energetic action than that which it is here supposed gave them their present form.

If we take the case of a powerful stream that is joined by a much smaller affluent—so small that its current produces no appreciable effect upon that of the main stream—it will be noticed that it very often happens at the point of junction that a kind of tangential action is set up by the two forces, so that part of the smaller stream is ponded back into its own channel and is compelled to move in a complete circle—backwards towards the head of the tributary, then round against the upper bank at the point of junction, and finally round into the direction of the main stream—before it can escape from its own channel. As a consequence, the shingle is often swept away so as to leave a bay similar in form to that of the eddy above. Many coums occur in North-Western England whose origin is capable of explanation in the most complete and satisfactory manner by supposing that the greater ice-streams behaved to their tributaries in the same way that a strongly-flowing river does to the weaker tributaries that it is joined by. For instance, the ice of some of the small valleys coming down from the Cross Fell Escarpment into the Eden Valley, must, on meeting with the powerful stream that swept *up* the valley from the south-west of Scotland over Stainmoor to the North Sea, have been affected by a kind of tangential action, so that much of the tributary ice at high levels was compelled to move backwards in a rudely circular direction until it merged into the direction of the main stream. As a consequence, we find that on nearly every one of these tributaries some of the higher lying scars, where the currents were freest to move, are ground into crater-like recesses that, when viewed from a distance, remind one of nothing so much as of gigantic pot-holes that have had one side cut away.

Where a stream flows over a rock that is much fissured, so that a great diversity of directions is imparted to the lower currents of the stream, we find that the whirling motion thus produced has caused the rock to be drilled into numerous pot-holes, which vary in shape, position, and size, with the rapidity of the stream, the nature of the rock, and the direction of the larger fissures. The resemblance between the valleys and coums of a mountainous district, as they are seen on a good hill-shaded map, to the wider joint fissures and pot-holes seen in a river's bed, strongly inclines one to the opinion that the analogy between them is complete in nearly every respect but that of size. In the one case, the pot-holes in the river's bed are due to the eddies caused by the variously directed minor currents resulting from the inequalities of the river's bed; in the other, the coums seem to be due to the much larger eddies caused by the variously directed valley streams in the great river, or rather sea, of ice that once overspread perhaps the tops of our highest mountains in the northern parts of our islands. In the one case, the pot-holes have been due to rapid and comparatively intense action in a brief space of time; in the other, their larger analogues, the coums, have received their form through slowly, and perhaps feebly, acting causes continuing throughout a period of time so long that we can form no conception of its immensity.

It will therefore be seen that it is here considered that, as the orgin of coums—the so-called Giant's Cauldrons of Sweden—the "round and deep holes with polished sides" that occur on the sides of the Swiss valleys in situations "where the form of the surface will not permit us to suppose that any cascade could ever have existed,"[1]—and the existence of similar pits in the rocky bed of lake basins—all admit of the most complete and satisfactory explanation on the assumption that the analogy between the behaviour of a glacier and that of a river, which is known to be almost complete in the puny representatives of the old ice-sheet,

[1] Lyell, Elements, 5th edition, p. 149.

was, under the extreme conditions that obtained during the ice-sheet period, complete in every respect, the hypothesis that many of these cauldron-like hollows are due to the eddying of the ice must be accepted until it can be shown that this hypothesis is clearly disproved by any of the facts.

III.—A Chapter in the History of Meteorites.

By Walter Flight, D.Sc., F.G.S.,

Of the Department of Mineralogy, British Museum.

(*Continued from page* 412.)

1853, February 10th.—Girgenti, Sicily.[1]

It is probable that the history of this fall has unfortunately been lost to science. Vom Rath has recently endeavoured, but without avail, to gather information from Gemmellaro, of Palermo, respecting what now appears to have been a shower of stones rather than the fall of a single meteorite, as hitherto supposed. Gemmellaro was unable in 1869 to discover any persons who witnessed the fall; as, however, it appears that two years after the occurrence Greg[2] was informed that an account had been printed in a Sicilian scientific journal, more particulars of the fall may yet be obtained.

The two fragments examined by vom Rath were partly covered with a black crust forming an undulating surface, with occasional little prominences that revealed the presence of nickel-iron. The structure of the rock is chondritic, of a light greyish white, is finely granular, appearing to the eye almost uniform in texture. A fractured surface exhibits a great number of exceedingly fine black lines which seem to have their origin in the crust, although, from their diminutive size (they are generally only to be recognized with a lens), it is, says the author, difficult to believe that they are filled with fused matter. (Compare with Meunier's observations on the black lines in the Aumières meteorite, page 401.) They form a tangled mesh-work enclosing the spherules and rounded crystalline grains of olivine; and they are most abundant round the granules of magnetic pyrites, which they occasionally traverse. The nickel-iron is less abundant than in the Pultusk meteorites, and besides forming rounded or hackly grains, occurs, as in the Krähenberg aerolite, in fine veins. The magnetic pyrites (troilite?), which is more abundant than the preceding mineral, takes different hues, and both it and the granules of chromite are grouped together in small circles, which give the rock a more distinctly chondritic character. Spherules of sufficient size to project from a fractured surface and capable of being detached are rare; some, however, have a fibrous structure and a pale green colour. Under the microscope the mass of the rock is found to be an aggregate of white crystalline grains; in it one

[1] G. vom Rath. *Pogg. Ann.*, 1869, cxxxviii. 541.—S. Meunier. *Compt. rend.*, 1873, lxxvi. 109.

[2] R. P. Greg. *Phil. Mag.* xxiv. 534.

small yellowish-green crystalline plate having the appearance of mica was noticed. The specific gravity of the stone is 3·549, a number intermediate between those yielded by the Pultusk and Krähenberg meteorites. The Girgenti stone contains 8·3 per cent. of nickel-iron having the composition:

Iron = 87 3; Nickel = 12·7; Total = 100·0.

Here again the proportion of this constituent is intermediate between that found in the meteorites just mentioned; and in composition nearly the same as the nickel-iron of Krähenberg.

The non-magnetic portion, amounting to 91·7 per cent., which, by reason of the small amount of material available for analysis, was not subjected to the separating treatment of acid, was found to consist of:

SiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O?	Fe	S	Chromite	
43·41	1·57	17·96	trace	26·84	1·85	1·50	3·43	2·24	1·20	= 100·00

If the chromite and the iron sulphide, which as it occurs in the portion of the stone unacted upon by the magnet is probably troilite, be deducted, the silicates have the following composition:

		Oxygen.
Silicic acid	46·61	24·19
Alumina	1·68	0·78
Iron protoxide	19·22	4·33
Magnesia	28·89	11·55
Lime	1·99	0·57
Soda (?)	1·61	0·66
	100·00	

The oxygen ratio of the total bases to that of the silicic acid is 1 : 1·352. As this is obviously a mixture of silicates, it seems not improbable, both from the structure of the stone and the analytical determinations, that it consists, as in the Krähenberg rock (see page 22), of an olivine of the form FeO, MgO, SiO_2 (like that also occurring in the meteorites of Château-Renard and Kakova), and a nearly pure magnesian enstatite, as the following scheme indicates:

	FeO, MgO, SiO_2. *Oxygen.*		MgO (CaO), SiO_2. *Oxygen.*	
Silicic acid	8·66		15·53	
Iron oxide	4·33	8·66	——	
Magnesia	4·33		7·22	7·79
Lime	——		0·57	

For the reason already mentioned the presence of cobalt and of the alkalies could not be directly determined.

Found 1854.—Tucson, Pima Co., Arizona.[1]

This remarkable mass of iron, of which an account is given in Bartlett's "Personal Narrative,"[2] has been chosen by von Haidinger

[1] W. von Haidinger. *Sitzber. Akad. Wiss. Wien*, lxi. April heft.

[2] J. R. Bartlett. Personal Narrative of Explorations and Incidents in Texas, New Mexico, California, Sonora, and Chihuahua. 1854. New York: Appleton & Co. Page 297.

to illustrate some remarks on the rotation of meteorites. It measures 4 ft. 1 in. by 3 ft. 3 in., weighs about 1400 lbs., and is in the form of a ring. When first found, it was set up as an anvil.

Von Haidinger points out that the greatest extension of the iron is in the plane of the ring, and that the rotation must have taken place in this plane. The question arises: What would be the effect the resistance of the air will exercise on a plate of iron of unequal thickness? In the centre of the compression, and therefore of the expansion, the air, he finds, would be compressed together in a condition resembling that of a solid body. What then will be the effect on a large mass of rock, the uneven surface of which is subjected to the unequal action of a temperature of fusion? The stone will be bored into, as the Gross-Divina stone has been to a considerable depth; a similar phenomenon has been remarked in other meteorites. While this will be the effect on brittle stony material, in the present case the resistance of the air, operating on a plate three to four feet in diameter of viscous metal, will be more rapid and energetic. The plate will in process of time be penetrated at one point, and by the gradual expansion of the orifice it will eventually develope into a ring, and arrive in this form on the earth's surface.

The meteoric iron which was seen to fall at Agram, Croatia (1751, May 26th), has the form of a plate, and bears evidence of having been subjected to the same eroding influence, though in a less degree. Had it been continued to the depth of another inch this iron would have been perforated, as in the case of the Tucson ring.

The above is a representation, one-twentieth the actual size, of this curious mass, which is preserved in the Smithsonian Institution, at Washington. The figure is reproduced from von Haidinger's memoir.

1855, June 7th.—St. Denis-Westrem, near Ghent, Flandre orientale, Belgium.[1]

The earlier descriptions of this meteorite are by Duprez[2] and Haidinger.[3] Meunier states that the rocky portion of this meteorite accords in all its characters with that of the stones which fell at Lucé, Sarthe, France (1768, September 13th), Mauerkirchen and others, as well as with that of the meteorite of Sauguis St. Étienne, Basses-Pyrénées (1868, September 7th). The latter rock, to which he has given the name of "lucéïte," is described as white and finely granular, rough to the touch and eminently crystalline, and having the specific gravity of 3·43. He reproduces from another of his memoirs the results of his examination of the last-mentioned stone, and to this we shall presently direct attention. No analysis of the Belgian meteorite appears to have been performed. The paper is chiefly devoted to theoretical considerations respecting the stratigraphical arrangement of the star-masses whence the meteorites are supposed to be derived. Meteorites, he maintains, are the product of the breaking-up of larger celestial bodies at the completion of their development, and the moon, he considers, is now approaching this stage of her existence.

Found 1856.—Hainholz, near Paderborn, Minden, Westphalia.[4]

This member of the small class of siderolites, originally described by Wöhler, von Reichenbach, and von Haidinger, has recently been submitted to a careful chemical examination by Rammelsberg. It was remarked by von Reichenbach that the olivine of this meteorite formed unusually large crystalline masses, the faces of which, however, were destroyed by weathering; one crystal was $1\frac{3}{4}$ in. long and $1\frac{1}{2}$ in. in breadth.

Two specimens of this meteorite were found by Rammelsberg to have the composition:

Nickel-iron	14·48	12·70
Chromite	0·58	10·52
Olivine	56·45	62·78
Bronzite	28·49	24·00
	100·00	100·00

The metallic portion consists of:

Iron = 93·84; Nickel = 6·16 Total = 100·00

and the two silicates have the following composition:

	SiO_2	Al_2O_3	FeO	MgO	CaO	
A. *Soluble*	35·77	—	22·91	41·32	—	=100·00
B. *Insoluble*	53·05	3·19	15·63	25·40	2·73	=100·00

[1] S. Meunier. *Bull. Acad. Sc. Belgique*, 1870 [2], xxix. 210. (See also F. Duprez, *Bull. Acad. Sc. Belgique*, 1870 [2], xxix. 161.)—Acad. royale de Belgique. Centième Anniversaire de Fondation (1772–1872). Tome II. *Rapport séculaire* (*Sciences minérales*), *par G. Dewalque*, 23.

[2] F. Duprez. *Bull. Acad. Sc. Belgique*, 1855 [2], x. 12.

[3] W. von Haidinger. *Sitzber. Ak. Wiss. Wien*, 1860, xlii. 9.

[4] C. Rammelsberg. *Monatsber. Akad. Wiss. Berlin*, lxx. 314.—C. Rammelsberg. Die chemische Natur der Meteoriten. *Abhandl. Akad. Wiss. Berlin*, 1870, 94. See also *Ber. Deutsch. Chem. Gesell. Berlin*, 1870, iii. 523.

The soluble part, which constitutes more than one-half of the stone, is an olivine in which the ratio Fe to Mg is 1 : 3, the same proportion as that met with in the Linn Co., Shergotty and other meteorites. In the insoluble portion we have a bronzite in which the ratio of these two metals is the same as that of the olivine accompanying it, and as that in the enstatite of the Shalka aerolite. In the latter meteorite the bronzite is not associated with nickel-iron. The constitution of these two ingredients of the Hainholz siderolite may be represented by the formulæ:

$$\left\{ \begin{matrix} Fe_2 SiO_4 \\ 3\ Mg_2 SiO_4 \end{matrix} \right\} \qquad \left\{ 8 \left\{ \begin{matrix} Fe SiO_3 \\ 3\ Mg SiO_3 \end{matrix} \right\} \atop Al_2O_3 \right\}$$

Found 1856 (?).—Jewell Hill, Madison Co., N. Carolina.[1]

This iron has been found by Tschermak to enclose thin plates of troilite like those he recently noticed in the meteoric iron of Ilimaë, Desert of Atacama, Chili. (See page 73.) The lamellæ are just as abundant and have the same orientation as those of the Chilian iron, and are about one-third the size. According to the analyses of Tschermak and Dr. Lawrence Smith, these metallic masses have nearly the same composition. In a volume of his papers collected and published in 1873, the latter author[2] states that the Jewell Hill iron reached his hands in 1854.

1857, February 28th.—Parnallee, Madura District, Madras, India. [Lat. 9° 14′ N.; Long. 78° 21′ E.][3]

Several notices of this remarkable fall, the larger aerolite of which is preserved in the National Collection, have appeared: three by von Haidinger, and three by 1). Cassels, by 2). Pfeiffer, who submitted the rock to analysis, and 3). by Maskelyne, who studied its minute structure under the microscope. Meunier publishes the results of a lithological study of this stone, which he finds to have a very complex structure, and to present in its leading features great similarity with the meteorites of Cabarras Co. (1849, October 31st), Mezö-Madaraz (1852, September 4th), and Bremervörde (1855, May 13th). Its structure has been described as pisolitic: Meunier, on the contrary, likens it to a coarsely granular grit. The grains composing it are often angular, sometimes more or less rounded, and in each instance have the characters of fragments which have been detached from larger masses: the rock, in short, is a breccia. By a careful examination of the four specimens preserved in the Paris Collection, the author has noted the presence of twelve distinct species of grains: 1). troilite, sometimes in fragments of large size; 2). nickel-iron, in rounded or markedly angular fragments; 3). greyish green translucent peridot, presenting the appearance of having been rolled; 4). chromite, enclosed in a whitish rocky matrix; 5). a grey

[1] G. Tschermak. *Denkschrift Wien. Akad. Math. Naturw. Classe*, xxxi. 187.
[2] J. L. Smith. Mineralogy and Chemistry, 317.
[3] S. Meunier. *Compt. rend.*, 1871, lxxiii. 346.

laminated mineral, with pearly lustre, which is probably hypersthene or amphibole. The remaining seven species, which may more appropriately be designated rocks proper, are divided by the author into two groups, according as he has, or has not, been able up to the present to identify them as individual lithological types constituting distinct meteorites. In the latter group he enumerates 6). a grey scoriaceous rock, free from metallic particles; 7). a dark grey rock, enclosing them; and 8). a bright grey slightly ochreous rock, probably the altered product of another species. Meunier is of opinion that any one of these three species may at some future period be found to constitute an individual meteorite. The remaining four species are: 9). a white granular rock, enclosing nickel-iron and troilite; this variety, which occurs in about thirty of the meteorites in the Paris Collection, he has termed lucéïte; 10). a rock of the whiteness of plaster and enclosing small black grains; this is the 'chladnite' of the Bishopville meteorite, now shown to be magnesian enstatite, MgO, SiO_2; 11). a rock, perfectly black and very tough, containing grains of nickel-iron and troilite, such a material, met with in the stone of Tadjéra (1867, June 9th) and the meteoric irons of Deesa and Hemalga, has received the name of tadjérite; and 12). the last species, is a greenish grey friable granular highly crystalline rock, containing no metal but small grains of chromite; from its resemblance to the meteoric rock of Chassigny (1815, October 3rd), and in fact by reason of its highly olivinous character, it has received the name of chassignite.

The presence, says the author, in the 'polygenic conglomerate' of Parnallee of fragments belonging to seven types at least of distinct meteoric rocks, demonstrates the co-existence of these types in the star-mass whence this Indian meteorite came.

1858, December 24th.—Murcia, Spain.[1]

This meteorite, which was shown at the International Exhibition of Paris in 1867, is in the form of a right parallelepiped with square base, the dimensions whereof are 39 centim., 40 centim., and 27 centim. It weighs 114 kilog., considerably surpassing in size the average of rock masses of meteoric origin.

This meteorite is remarkable for its hardness. The crust, which is nearly perfect, has evidently turned since the fall of the stone from black to brown. On the fractured surface grains of nickel-iron are seen, few of which retain their lustre, as well as an iron sulphide of a bronze hue which is abundantly disseminated through the mass. Besides these are remarked, what form a distinguishing feature of this rock, very small extremely brilliant crystalline particles, sometimes in minute veins, which appear to be metal, but really have vitreous lustre. They fuse before the blowpipe to a grey enamel, and give the reactions of silica and alumina. They are probably a

[1] S. Meunier. Thèse présentée à la Faculté des Sciences de Paris, 1869. *Recherches sur la composition et la Structure des Météorites*, 9, *et seq*. (See also G. A. Daubrée and S. Meunier. *Compt. rend.*, 1868, lxvi. 639.)

felspar or an analogous mineral species. Though by their brilliancy and transparency they resemble quartz, the feeble action which they exert on polarized light suffices to distinguish them. In a microscopic section the presence of a large amount of a black opaque ingredient was recognized; grains of a sulphide with a sub-metallic lustre, duller along the margin, are very abundant; while others much smaller and very black were identified with chromite. The stony matter enclosing these substances is made up of two ingredients of different aspect: the one, of a reddish-yellow colour and very transparent, presents the flawed characters usually observed in the siliceous portion of meteoric rocks; the other is of a darker hue and less homogeneous.

The material chosen for analysis, taken from the blackest, and consequently less altered portion of the meteorite, had the following composition:

Nickel-iron...	14·990
Troilite	20·520
Chromite	0·920
Soluble silicate	38·688
Insoluble silicate	24·640
	99·758

The nickel-iron consists of:

Iron = 90·93; Nickel = 9·07; Total = 100·00

The troilite, constituting one-fifth of the stone, is present in larger quantity than in any meteorite previously investigated. The siliceous portions are composed as follow:

	SiO_2	Al_2O_3	FeO	MgO	CaO	Na_2O	K_2O	Chromite	
A. *Soluble*	38·725	—	12·932	47·206	0·233	0·904	—	—	=100·000
B. *Insoluble*	55·719	1·996	0·880	37·806	—	—	trace	3·599	=100·000

The soluble portion consists chiefly of an olivine having the same composition as that occurring in the meteorites of Tadjéra and Pultusk, while the insoluble part appears to be for the most part a pure magnesian enstatite, with perhaps a small amount of the aluminous mineral already alluded to.

1858.—Trenton, Washington Co., Wisconsin. [Lat. 43° 22′ N.; Long. 88° 8′ W.][1]

In the autumn of 1858 a farmer while working on his farm in Section 33, Washington Co., struck his plough against some hard object about 10 inches below the surface; it proved to be a mass of meteoric iron weighing 62 lbs. It appears that four pieces, two of which weighed 16 lbs. and 7¾ lbs., were found, in the years immediately following, within a circuit of two or three rods of the spot where the largest was discovered. Dr. L. Smith gives the weights of the masses: 62 lbs., 16 lbs., 10 lbs., and 8 lbs., and the composition of the metal as written below (I.), side by side, with the

[1] J. L. Smith. *Amer. Jour. Sc.*, 1869, xlvii. 271. Mineralogy and Chemistry, 349.—F. Brenndecke. *Annual Rep. Smithsonian Inst. for* 1869, 1871, 417.—J. A. Lapham. *Amer. Jour. Sc.*, 1872, iii. 69. (See also Part I. Geol. Mag., page 30.)

results of an analysis by Bode (II.), which is incorporated in Brenndecke's report on these meteorites presented by him to the Society of Natural History of Wisconsin:

	I.	II.
Iron	91·03	89·22
Nickel	7·20	10·79
Cobalt	0·53	trace
Phosphorus	0·14	0·69
Copper	trace	—
Insoluble residue	0·45	—
	99·35	100·70
Specific gravity	7·82	7·327

Bode states that the Widmannstättian figures are developed with great distinctness. Dr. Smith arrived at the same result, and finds that the spaces between these figures, which have convex ends and sides, are darker in hue than they are, and exhibit striations, the lines being at right angles to the bounding surfaces; these forms he terms 'Laphamite markings.' When the space where they occur is nearly square the lines extend from each of the four sides; in other cases they are parallel to the longer sides. He considers that these figures indicate "the axes of minute columnar crystals, which tend to assume a position at right angles to the surface of cooling." The author does not describe what phases these figures assume when the iron is cut in various directions.

1859, May —.—Beuste, Basses-Pyrénées.[1]

This meteorite has recently been acquired for the Paris Collection. Two fragments, weighing respectively 1·40 and 0·42 kilog., were found about 700 metres apart, the former having penetrated the soil to a depth of about 50 centim. The black crust has a thickness of 0·4 to 0·5 mm., and the specific gravity of the stone is 3·53. It belongs to the class of which the Chantonnay meteorite (1812, August 5th) is a representative, and consists, it may be presumed, as it has not yet been analyzed, chiefly of olivine, bronzite, and labradorite. The stone has a grey colour and a compact structure. The fractured surface is traversed in all directions by black veins which anastomose.

1860, May 1st.—New Concord, near Zanesville, Guernsey Co. and Muskingum Co., Ohio.[2]

A note on the fall of these meteorites, copied from the *Zanesville Courier*, apparently contains no new information beyond what has already been recorded in Buchner's *Die Meteoriten*, 104.

Found 1861.—Rittersgrün, near Schwarzenberg, Saxony.

For a short description of the probable composition of this siderolite see the *Breitenbach Meteorite*.

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

[1] G. A. Daubrée. *Compt. rend.* 1873, lxxvi. 314.
[2] *Amer. Jour. Sc.*, 1871, i. 309.

IV.—On the Occurrence of the Genus *Cotylederma* in the Middle Lias of Dorsetshire.

By Thomas Wright, M.D., F.R.S.E., F.G.S.

PROFESSOR QUENSTEDT, in his Handbuch der Petrefaktenkunde (1852), first described and figured, under the name *Cotylederma*, a remarkable fossil which he found adherent to the surface of *Ammonites striatus* in the upper region of the Lias *c*. It formed a flat, sessile, cylindrical little bowl, composed of five plates, with five blunt angles, and was referred by him to the class Echinodermata and the order Crinoidea. The learned author, in his "der Jura" (1858), says that he has found it attached to *Ammonites lineatus* and *A. striatus* in the upper region of Lias γ, at Aselfingen, and that it was comparable to the calyx of a crinoid.

Professor E. Deslongchamps, in his valuable memoir: "Sur la Couche à Leptæna" (Mémoires de la Société Linnéenne de Normandie), described and figured several forms of this genus, which he had found in a very richly fossiliferous stratum of Middle Lias at May and Fontaine Etoupefour (Calvados). The *Cotylederma* are very singular Crinoids, of which we only know the Calyx or Pelvis. They have the form of little cups or tubes, and adhere directly by their base to submarine bodies without any trace of a stem. These remarkable fossils are very abundant at May, and from this locality Professor Deslongchamps obtained many specimens, among which are several new species, as *Cotylederma miliaris*, Desl., *Cot. fistulosa*, Desl., *Cot. docens*, Desl., *Cot. vasculum*, Desl., *Cot. Quenstedti*, Desl.

M. Terquem collected a species of *Cotylederma* sessile on an ammonite in the Middle Lias (Department of the Moselle), in a bed with *Ammonites Davœi*, Sow., and which was identified as the *Cotylederma Quenstedti*, Desl.

MM. Terquem and Ed. Piette (Lias Inférieur de l'est de la France, p. 123) have subsequently detected this genus in the Lower Lias Limestone with *Ammonites bisulcatus*, Brug., at Fleigneux and at Jamoigne in the East of France, where they found six individuals of different ages; five were attached to *Gryphæa arcuata*, Lam., and the sixth and largest specimen to *Pleurotomaria anglica*, Sow. These they have described and figured as *C. Oppeli*. "The base is firmly adherent, lobed into five or six divisions; the superior border thin, round; interior conical smooth. Dimensions: Diameter of the base, 6 millim.; diameter of the opening, 2 to 3 millim.; depth, 2 millim. The specimens are very rare."

My friend F. Longe, Esq., F.G.S., whilst examining the Lias Coast Section last August between Lyme Regis and Charmouth, found a nodule at the base of Down Cliffs which he thinks belongs to bed *d*, "Blocks of indurated Sandstone," of Mr. Day's memoir on the Middle and Upper Lias of the Dorsetshire Coast. (Quart. Journ. Geol. Soc., 1863, vol. xix. p. 285, fig. 4.) This nodule contained a specimen of *Cotylederma*, having a portion of shell adhering to its base. The fossil is conical, obliquely inclined to one side; the base is expanded, and was apparently adherent; and the summit is rounded and open. The body consists of five unequal-sized calcareous plates closely soldered together, and having their surface covered with small granulations. The plates are each slightly convex, and the lines of the sutures well defined. The species appeared to me to be identical with one of the forms figured by M. Deslongchamps in the memoir referred to from the Middle Lias of May.

Without committing myself to any opinion as to the true position of *Cotylederma* in the zoological series until I have an opportunity of examining the structure more in detail, I desire now only to record the fact of the discovery of this genus in the Middle Lias of Dorset, as it is the first English specimen of this curious form of the Liassic Sea which I have yet seen in any collection from our Lias beds.

NOTICES OF MEMOIRS.

I.—On the Discovery of Batrachia in the Upper Palæozoic Rocks of France. *Sur la découverte de Batraciens dans le terraine primaire, par M. Albert Gaudry.* Bulletin de la Société Géologique de France, 3e série, t. iii. p. 599, pl. vii. et viii.

IN the spring of the present year M. Albert Gaudry communicated an interesting paper to the Geological Society of France, on some newly discovered remains of true Batrachia found in the older rocks of that country, and which paper has just been published, with two plates, in their Proceedings. This discovery is palæontologically important; as the author observes that up to the present time no remains of actual typical Batrachia have been found in any rocks of earlier date than the Tertiary Period. It has also been a subject of surprise, that Vertebrates of so low an organization should have appeared so late upon the earth, and this supposed fact has been used as an objection to the theory of progressive development. However, this discovery, he thinks, shows structural characters, such as an evolutionist would expect to find in an ancient rock. The tail very short, the bones of the trunk and limbs resembling those of the Salamanders, whilst on the contrary the bones of the head have the characters of those of the Frog; thus lessening the distance which appears to separate the *Urodela* from the *Anoura*. He further remarks, that the incomplete ossification of the centra of the vertebræ, the want of ossification of the epyphyses of the limb bones, and probably, also, the cartilaginous state of the carpals and tarsals, reveal a type of which the evolution is not yet completed. Like the earlier Mammalia, these Batrachia are very small, thus giving them the appearance of animals not fully developed. But he thinks it probable that most of the individuals he examined were adults, for they varied but little in their proportions. The specimens were found at Muse (Saone et Loire), and at Millery, in the schists from which petroleum is extracted. At this place a slab was obtained showing remains of seven individuals more or less perfect. These schists are considered by some geologists to belong to the upper beds of the Coal-measures, but are more generally referred to the Permian Formation; but this diversity of opinion is of little importance in regard to these remains, as it is certain that these bituminous schists belong to the upper series of the Palæozoic rocks of France. Remains of seventeen individuals have been obtained, one only being from Muse; the two largest are respectively 45 and 35 millemetres long from snout to end of tail, whilst the Muse specimen is but 30 millemetres in length.

Although the skeleton appears smaller, M. Gaudry does not think it constitutes a specific difference. The osteological characters, and the points of agreement with, or divergence from, the corresponding bones in the Frogs and Salamanders, and also in some of the extinct genera of the Amphibia, are fully stated; but these comparisons, although interesting, are too long for quotation.

The osteological evidence for considering these remains to be those of true Batrachia are, the large size of the head of *Protriton*, the great eye orbits, the absence of the suprasquamosals, and also of the entosternum and episternum, together with the very small ribs, —these characters have a marked resemblance to the Batrachia, and more especially to the Salamanders. There are, however, some important differences; notably the head is relatively very much larger than that of the aquatic Salamanders, and is also proportionally larger than in the terrestrial Salamanders; the vertebræ are not so completely ossified; the neck has three vertebræ, the Salamander but one; the dorsal and lumbar vertebræ are shorter and more numerous; the ribs are less arched; the lumbar vertebræ carry no ribs, and the tail is only a fifth of the total length of the body, whilst in most of the Salamanders it is equal to the half of the entire length. The anterior and posterior limbs are directed backwards, thus more resembling the Ganocephala than the Batrachia. It is probable, when more perfect examples of *Protriton* are found, in which the bones of the scapular and pelvic arches are shown, that more numerous differences than those at present observed may separate *Protriton* from the *Urodela*.

M. Gaudry thinks that *Apateon pedestris*, v. Meyer, from the bituminous schists of Appel Münster, is closely allied to *Protriton*, and that Prof. Wyman is of opinion that *Raniceps* (*Pelion*) *Lyelli*, from the Coal-measures of Ohio, is also a true Batrachian. There is therefore evidence of the early existence in Geological time of members of this family in France, Germany and North America. He proposes the name *Protriton petrolei*, as indicating that these remains are the predecessors of the Salamanders, and that they were first found in rocks producing petroleum.—W. Davies.

II.—On the Formation of Metallic Sulphides and other Minerals in the Thermal Spring of Bourbonne-les-Bains (Haute-Marne). By M. Daubrée. Comptes Rendus, vol. lxxx. 1875.

In carrying out some works connected with the thermal spring of Bourbonne-les-Bains, some interesting facts have been brought to light. At the bottom of an ancient well, a bed of blackish mud was found, containing in its upper part many vegetable remains, and in the lower, numerous medals of bronze, silver and gold, as well as other works of art of Roman age. Below this was a bed consisting principally of fragments of sandstone, which were more or less cemented together by metalliferous minerals definitely crystallized.

M. Daubrée's attention was directed to this interesting circumstance by the Minister of Public Works, who had received specimens from the chief engineer of mines, M. Trautman.

Notwithstanding the resemblance of these minerals to those of older geological date, they have evidently been produced after the embedding of the Roman medals with which they were associated, for, in many instances, the medals were encrusted and enveloped by them. The following species were recognized:—

Copper Glance, in crystals similar to those found near Redruth, in Cornwall, and associated with Covelline.

Copper Pyrites crystallized and mammillated.

Erubescite in regular octahedrons, and cubes with faces slightly curved.

Tetrahedrite in crystals with its usual lustre and other characters, and from the analysis representing a type nearly free from arsenic.

Of these minerals, the most novel is the formation of the double sulphide of copper and antimony constituting Tetrahedrite, for the other species have been previously observed under somewhat similar conditions in other localities.

Besides these, occur numerous rounded grains of quartz, cemented with sulphides, as well as some doubly-terminated crystals of the same mineral, resembling the Compostella Hyacinth. Whilst some of these are derived from the *grès des Vosges*, others appear to have been the result of a contemporaneous crystallization with that of the Tetrahedrite, etc.

The formation of these sulphides is evidently connected with the thermal spring, the water of which contains in solution chlorides and sulphates of the alkalies, lime and magnesia, as well as bromides, and carbonates of iron and lime, an alkaline silicate, and traces of arsenic and manganese. The solid contents are about 7 to 8 grammes per litre, and the temperature is about 60°.

In explaining the formation of these metallic sulphides in the midst of the mud and under the influence of the mineral water which has constantly penetrated it, M. Daubrée considers that the sulphates have been partially reduced to sulphides by the action of the vegetable matter present, a well-known reaction in nature.

The presence of antimony, an essential element in tetrahedrite, is particularly interesting, for, though its presence has been determined in mineral springs in other localities, it has not been recognized at present in that of Bourbonne-les-Bains. It has been, therefore, probably derived from the minerals used in the manufacture of the bronzes, traces of this metal having been found in ancient bronze by M. Fellenberg.

The medals present a curious modification. Most of them, whilst retaining their general form, have lost their sharpness of outline, so that, while the interior still shows the lustre and colour of bronze, the exterior consists of a white earthy crust, consisting chiefly of oxide of tin, slightly coloured by traces of copper salts. Thus, by reason of the different chemical affinities of the metals composing the medals, the copper has entered into sulphur combinations, whilst the tin has passed into the state of oxide. This accounts for the mode of occurrence of tin, which is generally found in the state of oxide, even when sulphides, as mispickel, are found associated with it in the same vein. The antimony, notwithstanding its analogies with tin, differs from it in these modern products, as in metalliferous veins, by being invariably in combination with sulphur.

The silver medals are not altered.

Geologically short as is the time during which these reactions described by M. Daubrée have taken place, yet they supply important results, and afford new evidence of the influence of mineral springs in the formation of metallic sulphides, such as may partly assist in explaining the filling of mineral veins with similar substances.

Further research has brought to light other facts, as the occurrence of galena, anglesite, mammillated limonite, and iron pyrites.

The cavities in the bricks used in the conduit for the thermal waters are sometimes found lined with small rhombohedral crystals of chabasite, also some small colourless crystals having the form of rectangular prisms similar to those which occur under analogous circumstances at Plombieres, and which are referred to phillipsite or lime-harmotome.[1]

It thus appears that the zeolitic minerals of the two localities cited, as well as at Luxenil previously described by M. Daubrée,[2] are the result of similar reaction, producing silicates which did not originally exist in the concrete, but which have resulted from the long-continued action of the contents of the thermal waters upon the materials used in the construction of the conduit. It is to be remarked that the water of Bourbonne-les-Bains differs considerably from that of Plombieres, which contains a far less amount of soluble salts, about ·3 gramme per litre; this difference has, however, not affected the formation of zeolites in both.

M. Daubrée concludes by pointing out that thermal springs, flowing at limited depths and at slight pressure, produce mineral substances which have not yet been formed in our laboratories. How important, then, must be their effects at greater depths and greater pressure, reacting upon the different rocks which they traverse, and thus produce changes at present veiled to our view, but which should not be overlooked in the consideration of formations which come within the ken of the mineralogist and geologist.

J. Morris and Thomas Davies.

[1] Comptes Rendus, t. xlvi. p. 1806. (1858.)
[2] Bulletin de la Société Géologique, 2nd ser. t. xviii. p. 108. (1860.)

REPORTS AND PROCEEDINGS.

I.—June 23rd, 1875.—John Evans, Esq., V.P.R.S., President, in the Chair.

1. "Some Observations on the Rev. O. Fisher's Remarks on Mr. Mallet's Theory of Volcanic Energy, read May 12th, 1875." By Robert Mallet, Esq., F.R.S., F.G.S.

The subject of the Rev. O. Fisher's paper has been anticipated by one from Prof. Hilgard (Geol. Univ. of Michigan) published in the 'American Journal of Science' (vol. vii. June, 1874).

The pith of the Rev. O. Fisher's communication is to a great extent comprised in the two following sentences:—

1st. That "if crushing the rocks can induce fusion, then the cubes experimented upon ought to have been fused in the crushing?"

2nd. "If the work (of crushing) is equally distributed throughout, why should not the heat be so also? or if not, what determines the localization?"

In his reply Mr. Mallet controverts the views of the Rev. O. Fisher by bringing them into contact with acknowledged physical laws. He shows that "crushing alone of rocky masses beneath our earth's crust may be sufficient to produce fusion. He also shows that the heat developed by crushing alone cannot be equally diffused throughout the mass crushed, but must be localized, and that the circumstances of this localization must result in producing a local temperature far greater than that due to crushing. Lastly, he shows that after the highest temperatures have been thus reached, a still further and great exaltation of temperature must arise from detrusive friction and the movements of forcible deformation of the already crushed and heated material."

He therefore expresses his conviction that "there is no physical difficulty in the conception involved in his original memoir,[1] but not there enlarged upon in detail, that the temperatures consequent upon crushing the materials of our earth's crust are sufficient locally to bring these into fusion."

Discussion.—Prof Duncan remarked that this reply to Mr. Fisher's paper, which is not yet in print, was one which required careful thought and consideration. He thought that Mr. Mallet had not considered sufficiently the effects of tangential thrust. The curving of strata takes place along great planes, producing main synclinal curves; but there was another series of actions giving rise to thrusts over smaller areas. In any case the action of the thrust would be slow, and thus it can furnish no parallel to experiments by crushing rocks, in which the effect is rapidly produced. He further pointed out that volcanos do not follow mountain-chains, and that the crust of the earth has no doubt become more rigid than formerly, and that therefore tangential thrusts would now be less effective. Volcanic cones are found in older rocks than the Eocene.

Prof. Ramsay said that he agreed with Prof. Duncan in general, but thought that the meaning of quick and slow was difficult to define in connexion with great thicknesses of strata. If the pressure was sufficient to maintain motion, this might be quick in one sense and slow in another. Alterations may be gradually going on over great areas, by which means metamorphism may be evidenced in different degrees in different parts.

[1] Phil. Trans. 1873.

The President remarked that at a depth of 5 miles the pressure upon a rock would be 120,000 lbs. to the square inch, an element which, he thought, ought to be taken into consideration.

2. "On the Physical Conditions under which the Cambrian and Lower Silurian Rocks were probably deposited over the European Area." By Henry Hicks, Esq., F.G.S.

The author indicates that the base line of the Cambrian rocks is seen everywhere in Europe to rest unconformably upon rocks supposed to be of the age of the Laurentian of Canada, and that the existence of these Pre-Cambrian rocks indicates that large continental areas existed previous to the deposition of the Cambrian rocks. The central line of the Pre-Cambrian European continent would be shown by a line drawn from S.W. to N.E. along the south coast of the English Channel, and continued through Holland and Denmark to the Baltic. Its boundaries were mountainous; they are indicated in the north by the Pre-Cambrian ridges in Pembrokeshire, in the Hebrides and Western Highlands, and by the gneissic rocks of Norway, Sweden, and Lapland. The southern line commenced to the south of Spain, passed along Southern Europe, and terminated probably in some elevated plains in Russia. Between these chains the land formed an undulating plain, sloping gradually to the S.W., its boundary in this direction being probably a line drawn from Spain to a point beyond the British Isles, now marked by the 100-fathom line. The land here facing the Atlantic Ocean would be lowest, and would be first submerged, when the slow and regular depression of the Pre-Cambrian land took place.

The author points out that the evidence furnished by the Cambrian and Lower Silurian deposits of Europe is in accordance with this hypothesis. In England they attain a thickness of 25,000—30,000 feet; in Sweden not more than 1000 feet; and in Russia they are still thinner, and the earlier deposits seem to be wanting. In Bohemia they occupy an intermediate position as to thickness and order of deposition. The author discusses the phenomena presented by the Welsh deposits of Cambrian and Lower Silurian age, and shows that we have first conglomerates composed of pebbles of the Pre-Cambrian rocks, indicating beach conditions, then ripple-marked sandstones and shallow-water accumulations, and then, after the rather sudden occurrence of a greater depression, finer deposits containing the earliest organisms of this region, which he believes to have immigrated from the deep water of the ocean lying to the S.W. After this the depression was very gradual for a long period, and the deposits were generally formed in shallow water; then came a greater depression, marked by finer beds containing the second fauna; then a period of gradual subsidence, followed by a more decided depression of probably 1000 feet, the deposits formed in this containing the third or "Menevian" fauna. This depression enabled the water to spread over the area between the south of Prussia and Bohemia and Norway and Sweden, there being no evidence of the presence of the first and second faunas over this area. The filling up of this depression led to the deposition of the shallow-water deposits of the Lingula Flag group, followed by another sudden depression at the commencement of the Tremadoc epoch, which allowed the water to spread freely over the whole European area.

The author next discusses the faunas of the successive epochs, and indicates that these are also in favour of his views. He indicates the probability that the animals, which are all of marine forms, migrated into the European area from some point to the south-west, probably near the equator, where he supposes the earliest types were developed. Both the lower and higher types of invertebrates appear first in the western areas; and the groups in each case as they first appear are those which biologists now recognize as being most nearly allied, and which may have developed from one common type. The lower invertebrates appear at a very much earlier period than the higher in all the areas. In the Welsh area the higher forms (the Gasteropods, Lamellibranchs, and Cephalopods) come in for the first time in Lower Tremadoc rocks; and with the exception of the presence of a Gasteropod in rather lower beds in Spain, this is the earliest evidence of these higher forms having reached the European area. At this time, however, no less than five distinct faunas of lower invertebrates had already appeared; and an enormous period, indicated by the deposition of nearly 15,000 feet of deposits, had elapsed since the first fauna had reached this area. The author points out also that a simliar encroachment of the sea and migration of animals in a north-westerly direction occurred in the North American area at about the same time, the lines indicating the European and American depressions meeting in Mid-Atlantic.

3. "On a Bone-Cave in Creswell Crags." By the Rev. J. Magens Mello, M.A., F.G.S.

In this paper the author describes some fissures containing numerous bones, situated in Creswell Crags, a ravine bounded by cliffs of Lower Permian limestone, on the north-eastern borders of Derbyshire. These cliffs contain numerous fissures. The principal one described by the author penetrates about 50 yards into the rock and has a wide opening, but is very narrow throughout the greater part of its length. It runs nearly north and south, and inclines slightly from west to east, from the top downwards. Near the entrance there is a layer of surface soil six or seven inches deep, diminishing to about two inches a few yards in; this contains fragments of modern pottery, etc. A fine flint flake was found in this layer at about four inches from the surface. It is succeeded by a bed of red sand, containing rounded pebbles and rough blocks of Magnesian Limestone, which was cut into to a depth of four to five feet; it was full of bones, especially at a depth of two and a half or three feet downwards. Most of the long bones lay with their long axis parallel to the sides of the fissure and with their heavier ends foremost. An adjoining cave contained close to the surface some fragments of Roman pottery, together with bones of the common sheep; just below these, from three to four inches deep, were some molars of *Rhinoceros tichorhinus*, of the reindeer, and numerous chips of flint, and also some implements formed from pebbles. The organic remains found in the first fissure belong to fourteen mammals at least, besides a bird and a fish. The mammalia are—Man, *Lepus timidus*, *Gulo luscus*, *Hyæna spelæa*, *Ursus*, sp., *Canis lupus*, *Canis vulpes*, *Canis lagopus*, *Elephas primigenius*, *Equus caballus*, *Rhinoceros tichorhinus*, *Bos urus*, *Cervus megaceros*, *Cervus tarandus*, *Ovis*, sp., *Arvicola*, sp.

4. "Notes on Haytor Iron Mine." By Clement Le Neve Foster, Esq., B.A., D.Sc., F.G.S.

The Haytor mine is situated on the eastern borders of Dartmoor, about three-quarters of a mile from the pile of granite rocks from which its name is derived.

The iron-ore occurs in the form of magnetite interstratified with altered shales and sandstones of Carboniferous age, which strike about E. 25° S., and dip northwards at an angle of about 30°.

Near the iron-ore the rock becomes highly charged with hornblende, and is sometimes apparently entirely made up of actinolite. Garnets occur in great abundance.

The following section is shown in the adit level, viz. :—

Carboniferous rock.	
Iron-ore with partings of rock	10 ft.
Carboniferous ... ... about	6 ft.
Iron-ore with partings of rock	14 ft.
Carboniferous ... ... about	3 ft.
Granite-vein...	8 in.
Iron-ore...	6 ft.

A fourth bed, about 3 ft. thick, is seen cropping out about 300 yards N.E. from the others.

The granite-vein is intruded, not interbedded. The outcrop of these beds of magnetite may be traced eastwards for a distance of about three-quarters of a mile. The author considers the iron-ore to be simply an altered stratified deposit, and not an igneous trap.

5. "On the Formation of the Polar Ice-cap." By J. J. Murphy, Esq., F.G.S.

The present paper is intended by the author to supplement a previous one, read before the Society in 1869 (Q. J. G. S. vol. xxv. p. 350), in which he gave reasons for differing from Mr. Croll in thinking that the glacial climate was one of intense cold, and held, on the contrary, that it was one of snowy winters and cold summers, with a small range of temperature.

Mr. Campbell, in a paper read before the Society in 1874, gave the following as the southernmost limits of the Polar ice-cap, viz. :—In Eastern Europe lat. 56° N.; in Germany 55°; in Britain nearly 50°; in America 39°. This the author considers as strong, but not new evidence against the theory of an ice-cap extending to low latitudes; the extent of the ice-cap would, of course, not be so wide as that of the limits of glaciation, owing to the floating ice approaching nearer the equator. After commenting on Mr. Belt's remarks made during the discussion of Mr. Campbell's paper, the author states that he attributes the presence of the boulders found in the valley of the Amazon to icebergs which had drifted further than usual. The glaciation of the tropics would imply the glaciation of the whole world, which appears no more possible than that the whole world was submerged at one time. The author concludes with some remarks on a recent paper by Mr. A. Tylor.

6. "Notes on the Gasteropoda of the Guelph Formation of Canada." By Professor H. Alleyne Nicholson, M.D., D.Sc., F.R.S.E., F.G.S.

The author notices the occurrence of the Guelph formation as a subdivision of the Niagara series in Canada and the United States, and describes it as consisting everywhere of a cellular, yellowish or cream-coloured dolomitic limestone, of rough texture and crystalline aspect, containing innumerable cavities from which fossils of various kinds have been dissolved out. Most of the fossils still existing in the formation are in the condition of casts. The most characteristic forms which have been recognized in it are *Pentamerus occidentalis* (Hall), various species of Trimerellidæ, *Megalomus canadensis* (Hall), species of *Favosites* and *Amplexus*, and numerous Gasteropods belonging chiefly to the genera *Murchisonia*, *Pleurotomaria*, *Subulites* and *Holopea*. Crinoids and Cystidians and Polyzoa occur abundantly in some localities.

In this paper the author describes all the known Gasteropoda of the Guelph formation in Canada, including the following previously described species:—*Murchisonia Loganii* (Hall), *M. turritiformis* (Hall), *M. macrospira* (Hall), *M. bivittata* (Hall), *M. longispira* (Hall), *M. vitellia* (Billings), *M. Hercyna* (Billings), *Cyclonema? elevata* (Hall), *Holopea guelphensis* (Billings), *H. gracia* (Billings), *Subulites ventricosus* (Hall), and *Pleurotomaria solarioides* (Hall). As new species he describes *Murchisonia Boylei*, distinguished from *M. turritiformis* (Hall) and *M. estella* (Billings) by its more rapid rate of expansion, its apparently canaliculated suture, and the existence of an angular band a little above the suture; and *Holopea? occidentalis*, distinguished by its short but elevated spire, its large body-whorl, which becomes almost disjunct at the aperture, its circular aperture and large umbilicus. The upper whorls are convex, but the body-whorl is obtusely angulated at about its upper fourth. Uncertain species of *Murchisonia* and *Pleurotomaria* are also indicated.

7. "Description of a New Genus of Tabulate Coral." By G. J. Hinde, Esq., F.G.S.

The coral described by the author as constituting a new genus of Favositidæ, for which he proposes the name of *Sphærolites*, has a massive, free corallum, consisting of minute, polygonal, closely united corallites, growing in all directions from a central point, forming a spheroidal body, the entire surface of which is occupied by the calices of the corallites. The walls of the corallites are very delicate, with numerous pores; the tabulæ are incomplete, formed by delicate arched lamellæ; and there are no septa. From *Chætetes* this genus is distinguished by the perforated walls and incomplete arched tabulæ; from *Favosites* it differs in its mode of growth and its incomplete tabulæ; and from *Michelinia* it is separated by the minuteness of its corallites, and the absence of epitheca and of septal striæ.

The single species, which is named *S. Nicholsoni*, is from calcareous shale of Lower Helderberg (Ludlow) age, near Dalhousie, in New Brunswick.

8. "On the Superficial Geology of the Central Region of North America." By G. M. Dawson, Esq., Assoc. R.S.M., Geologist to H.M. North American Boundary Commission. Communicated by Dr. Bigsby, F.R.S., F.G.S.

Physical geography of the region.—The region under consideration is that portion of the great tract of prairie of the middle of North America from Mexico to the Arctic Sea, which lies between the 49th and 55th parallels, and extends from the base of the Rocky Mountains to a ridge of Laurentian rocks that runs N.W. from Lake Superior towards the Arctic Seas, and is called by the author the "*Laurentian axis.*"

This plateau is crossed by two watersheds; one, starting from the base of the Rocky Mountains at about the 49th parallel, runs due east to the 105th meridian, when it turns to the S.E., dividing the Red River from the Missouri; the other crosses from the Rocky Mountains to the Laurentian axis near the 55th parallel. The whole region between these two transverse watersheds slopes gradually eastward, but is divisible into three prairie *steppes* or plateaus of different elevations. The lowest includes Lake Winnipeg and the valley of the Red River; its average altitude is 800 ft. The second, or the "*Great Plains,*" properly so called, has an average elevation of 1600 ft. The third or highest is from 2500 to 4200 ft. above the sea, and is not so level as the other two.

Glacial phenomena of the Laurentian axis.—The neighbourhood of the Lake of the Woods is taken by the author as furnishing an example of the glaciation visible in many parts of the Laurentian axis. This lake is 70 miles long, and has a coast line of 300 or 400 miles. The details of its outline closely follow the character of the rock, spreading out over the schistose and thinly cleavable varieties, and becoming narrow and tortuous where compact dioritic rocks, greenstone, conglomerate, and gneiss prevail. The rocks both on the shores and the islands in the lake are rounded, grooved, and striated. The general direction of the striæ is from N.E. to S.W.

Drift Plateau of Northern Minnesota and Eastern Manitoba.—This plateau consists of a great thickness of drift deposits, resting on the gently sloping foot of the Laurentian, and is composed to a depth of 60 feet or more of fine sands and arenaceous clays, with occasional beds of gravel and small boulders, probably reposing throughout on boulder-clay. The only fossil found was a piece of wood apparently of the common cedar (*Thuja occidentalis*).

The surface of the plateau is strewn with large erratics, derived chiefly from the Laurentian and Huronian to the north; but there are also many of white limestone. The fossils in some of the latter being of Upper Silurian age, the author is inclined to believe, with Dr. Bigsby, that an outcrop of Upper Silurian is concealed by the drift deposits in the Lake of the Woods region.

Lowest Prairie Level and Valley of the Red River.—This prairie presents an appearance of perfect horizontality. The soil consists of fine silty deposits, arranged in thin horizontal beds, resting on till or boulder-clay. Stones were exceedingly rare. The western escarpment was terraced and covered with boulders. It is therefore probable that this prairie is the bed of a preglacial lake.

The *Second Prairie Plateau* is thickly covered with drift deposits, which consist in great part of local débris, derived from the underlying soft formations, mixed with a considerable quantity of transported material, especially in the upper layers. Large erratics are in places abundant; they consist mainly of Laurentian rocks, but Silurian limestone also abounds. The following is the per-centage of the boulders from the different formations present in the drift:—Laurentian 28·49, Huronian 9·71, Limestone 54·01, Quartzite Drift 1·14. The last is derived from the Rocky Mountains, the other three from the Laurentian axis. There are also on the surface of this plateau some remarkable elevated regions, apparently entirely composed of accumulated drift materials.

Edge of the Third Prairie Plateau, or the *Missouri Coteau*, is a mass of glacial débris and travelled blocks averaging from 30 to 40 miles in breadth, and extending diagonally across the country for a distance of about 800 miles.

Third or Highest Plateau.—There is a marked change in the drift on this plateau, the *quartzite drift* of the Rocky Mountains preponderating, seldom showing much glaciation. Its general character may be seen from the following per-centage of its composition:—Laurentian 27·05, Huronian ? Limestone 15·84, Quartzite drift 52·10. Some of the lower parts of this steppe show thick deposits of true till with well-glaciated stones, both from the mountains and the east, and débris from underlying Tertiary beds, all in a hard yellowish sandy matrix. On the higher prairie sloping up to the Rocky Mountains the drift is entirely composed of material derived from them.

The *Rocky Mountains* themselves show abundant traces of glaciation. Nearly all the valleys hold remnants of moraines, some of them still very perfect. The harder rocks show the usual rounded forms, but striation was only observed in a single locality, and there coincided with the main direction of the valley. The longer valleys generally terminate in *cirques*, with almost perpendicular rock-walls, and containing small but deep lakes.

State of the interior region of the continent previous to the Glacial Period.—The author considers that previous to the glacial epoch the country was at about its present elevation, and that its main physical features and river-drainage were already outlined. Subaërial denudation had been in operation for a vast period of time, and an enormous mass of Tertiary and Cretaceous strata removed.

Mode of Glaciation and Formation of the Drift Deposits.—The author did not find any evidence rendering the supposition of a great northern ice-cap necessary, but suggests that local glaciers on the Laurentian axis furnished icebergs laden with boulders, which were floated across the then submerged prairies towards the Rocky Mountains.

9. "On some important Facts connected with the Boulders and Drifts of the Eden Valley, and their bearing on the Theory of a Melting Ice-sheet charged throughout with Rock-fragments." By D. Mackintosh, Esq., F.G.S.

In this paper the main object of the author is to defend generally received opinions, especially as regards the great glacial submergence, in opposition to the theory announced in the Quart. Journ. Geol. Soc. for last February (vol. xxxi. p. 55). He brings forward a number of facts and considerations, founded on repeated observations, to show that the dispersion of Criffell granite-boulders is so interwoven with that of boulders of porphyry and syenite from the Lake-district as to be incompatible with the theory of transportation by currents of land-ice; and that the limitation of Criffell boulders along the S.E. border of the plain of Cumberland to about 400 feet above the sea-level is inconsistent with the idea of a boulder-charged ice-current 2400 feet in thickness. He likewise calls attention to the interweaving of Criffell with Shapfell granite in the lower part of the Eden Valley at too acute an angle to be satisfactorily explained by upper and under currents of land-ice. He remarks that Mr. Goodchild has not taken into account the dispersion of numerous Shap-granite boulders over ground at least 1300 feet above the sea-level as far south as Milnethorpe. He defends the idea of a special dispersion of surface-blocks of Shap granite, and believes that the limited altitude they have reached on Stainmoor is opposed to the theory of a boulder-charged ice-current 2300 feet in thickness, while an ice-current only 1500 feet in thickness on Stainmoor could not have persisted in carrying the boulders over opposing eminences as far as Bridlington on the Yorkshire coast. The author still further believes that the sudden disappearance of the ice-sheet can be better explained by the encroachment of the sea than by the subaërial melting of the ice. But his main argument against the theory of land-ice "charged throughout with rock-fragments of all sizes" is derived from the purity of the interiors of existing ice-sheets; and he quotes Professor Wyville Thomson in support of his statements.

10. "Observations on the unequal distribution of Drift on opposite sides of the Pennine chain, in the country about the source of the river Calder, with suggestions as to the causes which led to that result, together with some notices on the High-level Drift in the upper part of the Valley of the river Irwell." By John Aitken, Esq., F.G.S.

The author, in calling attention to the unequal distribution of the drift on the opposite side of the Pennine chain in this district, points out that on the western side of that range an extensive series of drift-deposits is found, spreading over the great plains of Lancashire and Cheshire down to the Irish Sea. It also occurs on the west flanks of the chain at elevations of from 1100 to 1200 feet, thus rising several hundred feet above the watersheds of some of the valleys penetrating that elevated region. On the eastern side, however, there is, with one or two slight exceptions, an entire absence of such accumulations, even in the most sheltered and favourable situations, for a distance of 12 or 15 miles from the water-parting of the country.

This absence of drift on the eastern side might, the author considers, be satisfactorily accounted for by supposing that the transverse valleys of the chain were, during the glacial epoch, completely blocked up with congealed snow or ice, by which means all communications between the opposite sides of the range would be entirely cut off. The southward flow of the ice, which was probably not so thick as to cover the higher portions of the chain, would, on encountering such an obstacle to its progress, be deflected westwards, and finally debouch into the plains of South Lancashire, and would there deposit on its retreat the débris it contained.

11. "On the Granitoid and Associated Metamorphic Rocks of the Lake-district." By J. Clifton Ward, Esq., M.A., F.G.S.

PART I. *On the Liquid Cavities in the Quartz-bearing Rocks of the Lake-district.*

The object of this paper was to examine into the evidence afforded by the liquid cavities of the granitoid rocks of the Lake-district, with reference to the pressure under which these rocks may have consolidated. In the first division of the subject the geological relations of the three granitic centres of the district were considered, and it was shown that these several granitic masses probably solidified at depths varying from 14,000 feet to 30,000 feet. The most probable *maximum* depth for the Skiddaw granite was stated as 30,000 feet; the *maximum* for the Eskdale granite 22,000 feet; and for the Shap granite 14,000 feet. These maximum depths were arrived at by estimating the greatest thickness of strata that were ever, at one time, accumulated above the horizon of the top of the Skiddaw slates.

The mode of microscopic examination, together with a description of the precautions taken in measuring the relative sizes of the cavities and their contained vacuities, formed the second division of the paper. It was stated that all the measurements used in the calculations were made from cases in which the vacuity mixed freely in the liquid of the cavity, and an approximately *perfect* case for measurement was defined to be one in which the outline of the liquid cavity was sharply defined all round in one focus, and in which the vacuity moved freely to every part of the cavity *without going out of focus.*

Then followed the general results of the examination. Restricting the measurements to such cases as those above mentioned, the results were found to be generally consistent with one another, and with those previously obtained by Mr. Sorby in his examination of other granitic districts. From the fact that the calculated pressure in feet of rock was in all cases greatly in excess of the pressure which could have resulted from the thickness of overlying rocks, it was inferred as probable that these granitic masses were not *directly* connected with volcanic action, by which the pressure might have been relieved, but that the surplus pressure was spent in the work of elevation and contortion of the overlying rocks.

Microscopic, combined with field evidence, was thought to indicate that the Shap granite, though mainly formed at a depth similar to that at which the Eskdale granite consolidated, was yet itself finally *consolidated* at a much less depth, the mass having eaten its way upwards at a certain point, and perhaps representing an unsuccessful effort towards the formation of a volcanic centre.

The examination showed that the *mean* of the pressures under which the Lake-district granites probably consolidated was nearly the same as the *mean* which Mr. Sorby arrived at for those of Cornwall. In conclusion the author stated that he wished these results to be considered as preliminary only, since the *complete* investigation would necessarily occupy far more time than was at his disposal; at the same time he ventured to hope that *general* accuracy was insured, while pointing to the many little-known causes which might affect the conclusions.

Part II. *On the Eskdale and Shap Granites, with their associated Metamorphic Rocks.*

The author brought forward evidence in this Paper to prove the possibility of the formation of granite by the extreme metamorphism of volcanic rocks. The passage is shown in the field, and may be observed in a complete series of hand specimens. Frequently, indeed, the actual junction is well marked, but in other cases the transition is gradual; and there occur at some little distance from the main mass, inlying patches of what may be called Bastard granite. The microscopic examination proves the passage from a distinctly fragmentary (ash) to a distinctly crystalline rock, and to granite itself. Also the chemical composition of the altered rocks agrees very closely with that of the granite.

Both Eskdale and Shap granite were believed to have been formed *mainly* from the rocks of the volcanic series by metamorphism at considerable depths; but the granite of Shap was thought to be in great measure intrusive amongst those particular beds which are now seen around it. A decided increase in the proportion of phosphoric acid was noted in the volcanic rocks on approaching the granite, and a decrease in carbonic acid.

12. "On the Correlation of the Deposits in Cefn and Pontnewydd Caves, with the Drifts of the neighbourhood." By D. Mackintosh, Esq., F.G.S.

Believing that the time has arrived for making some attempt to correlate cavern-deposits with glacial and interglacial drifts, the author ventures to bring forward the results of a personal examination of the remnants of the deposits in Cefn and Pontnewydd caves, compared with old accounts given by Mr. Joshua Trimmer and others. He has been led to regard the following as the sequence of deposits before the caves were nearly cleared out (order ascending):—1. Loam with bones and smoothly rounded pebbles, nearly all local (cemented into conglomerate in Pontnewydd cave). As a few foreign pebbles of felstone have been found in this bed, it could not have been deposited by the adjacent river Elwy before the great glacial submergence; and the author gives reasons for believing that it was not introduced by a freshwater stream from the boulder-clay above in Postglacial times, but that it may possibly represent the middle drift of the plains, and may have been washed in by the sea during the rise of the land. After emergence, and during a comparatively mild interglacial period, bones of animals may have been introduced by rain through fissures in the roof of the cave, and these may have become partly mixed up with the underlying pebbly deposit. 2. Stalagmite, from less than an inch to two feet in thickness, accumulated during a continuance of favourable conditions (apparently absent in Pontnewydd cave). Bones of animals were again brought in by rain or by hyænas, and were afterwards worked up into the following deposit:—3. Clay, with bones, angular and subangular fragments of limestone, pebbles of Denbighshire sandstone, felstone, etc. (palæolithic flint-implements and a human tooth in Pontnewydd cave according to Professor T. M'Kenny Hughes). This clay once filled the Cefn cave nearly to the roof. There are reasons for believing that it was principally introduced through the mouth of the cave, that it is of the same age with the neighbouring upper boulder-clay, and that it is not a freshwater redeposit of that clay. It was probably washed in during a second limited submergence. 4. Loam and coarse sand charged with minute fragments of sea-shells. Portions of this deposit may still be found in the Cefn cave; and it may have been introduced through fissures in the roof by the sea as the land was finally emerging.

13. "Geological Notes from the State of New York." By T. G. B. Lloyd, Esq., C.E., F.G.S.

The substance of this paper comprises notes, accompanied by drawings and sketches of various matters of geological interest which fell under the author's observation whilst residing some years ago in the State of New York.

The different subjects are divided under the following heads:—

(1) Groovings and channelings in limestone running across the bed of Black River at Watertown, Jefferson Co.

(2) Descriptions of the superficial beds of boulder-clay, sand, and gravel which were exposed to view in the district around the village of Theresa during the construction of the Black River and Morristown railroad.

(3) A description, with a general and detailed drawing to scale, of a remarkable "Giant's Kettle" near Oxbow, in Jefferson Co. It has been excavated out of a mass of Laurentian gneiss, which now forms a precipitous cliff, about 100 feet above the river Oswegatchie. The kettle is 28 feet in depth, with an average width of about 8 or 9 feet. It presents a striking resemblance in form to some of those occurring near Christiania.

(4) An account of some peculiar flower-pot-shaped blocks of sandstone discovered in a quarry of Potsdam sandstone at the village of Theresa. The quarry is situated upon the summit of a narrow gorge, through which the Indian river passes. The bed-rock is a hard, whitish-coloured sandstone, streaked with oxide of iron, and passes in places into quartzite. The blocks of stone, as extracted by the quarrymen, were shaped like cheeses. One of them measured 2 feet in diameter at the top, and 1 foot 6 inches across the bottom. Their depths varied with the thickness of the beds of rock from which they were extracted. They were coated with a thin crust of oxide of iron.

There were no signs of any markings upon them. Prof. James Hall, of Albany, has informed the author that the true nature of the blocks remains doubtful.

The author in conclusion refers to a statement in a paper on Niagara by Mr. Belt, F.G.S., published in the Quart. Journal of Science for April, 1875, in which it is stated that the sections described as occurring near the Falls are typical of the superficial beds that mantle the whole of the northern part of the State of New York and Ohio and much of Canada. He is unable to find any description of a deposit which bears a near resemblance to the boulder-clay occurring in the district around the village of Theresa, in the descriptions of various authors of the superficial deposits of the northern part of the State of New York and Canada. He therefore ventures to remark that no section can be considered as typical of the whole of the north part of the State of New York which does not recognize the existence of the deposit in question.

14. "On a Vertebrate Fossil from the Gault of Folkestone, which also occurs in the Cambridge Greensand." By Prof. H. G. Seeley, F.L.S., F.G.S.

The author describes a bone having the general form of an incisor tooth obtained from the Gault of Folkestone by Mr. J. S. Gardner, F.G.S. The flattened cylindrical end of a specimen from the Cambridge Greensand has been figured as a caudal vertebra of *Pterodactylus simus*. A microscopic section of the expanded end of a specimen from the Cambridge Greensand exhibits ordinary osseous tissue, showing that the fossil is probably a dermal spine from the tail of a Dinosaur. The Gault specimen is smaller than the examples from Cambridge.

II.—British Association for the Advancement of Science, Bristol, August 26th to September 1st, 1875. List of Papers Read before Section C. (Geology.)

President.—Dr. Thomas Wright, F.R.S.E., F.G.S.

The President's Address.

Handel Cossham, F.G.S., Edward Wethered, F.G.S., and *Walter Saise, F.G.S., Assoc. R. Sch. Mines.*—The Northern End of the Bristol Coal-field.

J. MacMurtrie, F.G.S.—On certain isolated areas of Mountain Limestone at Luckington and Vobster.

C. Moore, F.G.S.—On the age of the Durdham Down deposits yielding *Thecodontosaurus*, &c.

W. Pengelly, F.R.S.—Eleventh Report on the Exploration of Kent's Cavern, Torquay.

R. H. Tiddeman, M.A., F.G.S.—Report on the Exploration of the Victoria Cave, Settle.

Rev. H. W. Crosskey, F.G.S.—Third Report on Committee on Erratic Blocks in England and Wales.

E. B. Tawney, F.G.S.—On the age of the Cannington Park Limestone, and its relation to Coal-measures south of the Mendips.

W. W. Stoddart, F.G.S.—On Auriferous Limestone at Walton, near Clevedon.

Professor H. A. Nicholson, D.Sc., F.G.S., and *C. Lapworth, F.G.S.*—On some sections of the Silurian Rocks.

Professor T. McK. Hughes, M.A., F.G.S.—Notes on the classification of the Sedimentary Rocks. Part I.—The Lower Group, up to the top of the Old Red Sandstone. Part II.—The Upper Group, from the top of the Old Red Sandstone to Recent.

Henry Hicks, F.G.S.—On some areas where the Cambrian and Silurian Rocks occur as conformable series.

J. R. Mortimer—On the Distribution of Flint in the Chalk of Yorkshire.

H. Willett, F.G.S., and *W. Topley, F.G.S.*—Third Report on the Sub-Wealden Exploration.

Professor E. Hébert—Ondulations de la Craie dans le Nord de la France, et leur existence probable sous le Detroit de Douvres. [Undulations of the Chalk in the North of France, and their probable existence under the Straits of Dover.—Translated to the Section by *G. A. Lebour.*]

D. Mackintosh, F.G.S.—On the Geological meaning of the term "River-basin," and the desirability of substituting "Drainage area."

D. Mackintosh, F.G.S. — On the origin of Two Polished and Sharpened Stones from Cefn Cave, North Wales.

Professor E. Hull, F.R.S.—Observations on the discovery by Count Abbot Castracane of Diatomaceæ in the Coal of Lancashire and other places. (See Geol. Mag. 1875, p. 414.)

W. Sanders, F.R.S.—On certain large bones in Rhætic beds at Aust-Cliff, near Bristol.

Rev. P. B. Brodie, F.G.S.—On the further extension of the Rhætic or Penarth beds in Warwickshire, Leicestershire, Lincolnshire, Nottinghamshire, Yorkshire, and Cumberland, and on the occurrence of some supposed remains of *Labyrinthodon* and a new Radiate therein.

W. J. Harrison--On the occurrence of Rhætic beds near Leicester.

Dr. Th. Wright, F.R.S.E.—Note on the Reptilian remains from the Dolomitic Conglomerate on Durdham Down.

H. Woodward, F.R.S.—Tenth Report on British Fossil Crustacea.

H. Woodward, F.R.S.—On the discovery of a Scorpion in British Coal-measures.

H. Woodward, F.R.S.—On a new Orthopterous Insect from the English Coal-measures.

Dr. W. B. Carpenter, F.R.S.—On the origin of the Red Clay found by the *Challenger* at great depths in the Ocean.

W. H. Baily, F.G.S. — On a new species of Labyrinthodont Amphibia from Jarrow Colliery, Co. Kilkenny.

J. Hopkinson, F.G.S.—On the distribution of the Graptolites in the Lower Ludlow Rocks, near Ludlow.

Professor H. A. Nicholson, D.Sc.—On Azygograpsus—a new genus of Graptolites from the Skiddaw Slates.

J. E. Taylor, F.G.S.—On the Discovery of a Submerged Forest in the Estuary of the Orwell.

J. G. Grenfell, M.A., F.G.S.—Notes on Carboniferous Encrinites from Clifton and from Lancashire.

Rev. J. Brodie—On the Action of Ice in what is usually termed the Glacial Period.

Rev. W. S. Symonds, F.G.S.—On Changes of Climate during the Glacial Epoch.

D. Mackintosh, F.G.S.—Queries and Remarks relative to existing Ice-action in Greenland and the Alps, compared with former Ice-action in N.W. of England and Wales.

Rev. J. Gunn, F.G.S.—On the Influx and Stranding of Icebergs during the so-called Glacial Epoch; and a suggestion of the possible cause of the Oscillation of the Level of Land and Water to which that influx may be due.

Dr. C. Ricketts, F.G.S.—The Cause of the Glacial Period with reference to the British Isles.

E. Fry—On Moraines as the retaining walls of Lakes.

G. H. Kinahan, F.G.S.—The drifting power of Tidal Currents and that of Wind-waves.

Rev. J. Brodie—On the action of Ice moved by the Tide.

W. A. Traill, M.R.I.A.—On a mass of Travertine or Calcareous Tuff called "The Glen Rock," near Ballycastle, Co. Mayo.

Dr. W. B. Carpenter, F.R.S.—On the condition of the Sea Bottom of the North Pacific, as shown by the Soundings recently taken by U.S. Steamship *Tuscarora*.

J. Thompson, F.G.S.—On a new genus of Rugose Corals from the Mountain Limestone of Scotland.

E. Charlesworth, F.G.S.—On the discovery of a Molar of *Halitherium* and Molar of *Hippopotamus* associated with other remarkable Fossils in the Red Crag of Suffolk.

C. E. De Rance, F.G.S.—Report on the underground Waters in the New Red Sandstone and Permian formations of England.

Professor A. S. Herschel and *G. A. Lebour, F.G.S.*—Report on the conductivity for heat of certain Rocks.

Dr. Bryce, F.G.S.—Report on Earthquakes in Scotland.

Dr. J. Hector, F.R.S.—On the Geology of New Zealand.

Professor A. H. Green, M.A., F.G.S.—Notes on the method of deposition of the Millstone-grit of North Derbyshire and South Yorkshire.

G. A. Lebour, F.G.S.—On the limits of the Yoredale series in the North of England.

Dr. C. Le Neve Foster, B.A., F.G.S.—Notes on the Deposit of Tin at Park of Mines, St. Columb, Cornwall.

W. Topley, F.G.S.—On the Phosphorite Lodes of Estramadura; and on a deposit of Apatite at Jumilla, Murcia.

W. Topley, F.G.S.—Notes on some Wealden Conglomerates, containing large pebbles and rolled Ammonites.

Professor J. Tennant, F.G.S.—Notes on the South African Diamonds.

BOULDER-CLAY IN IRELAND.

Sir,—I can assure Mr. Birds that he is perfectly correct in supposing that there is an Upper Boulder-clay in Ireland, resting on "Middle Sands and Gravels;" and these again on the Lower Boulder-clay or Till. The general series is precisely similar to that of the North-west of England, to which he refers in his letter in the Geol. Mag. for September last (p. 429). If former sections which I had examined had left any doubt on this question on my mind, it would have been removed on seeing the section of the Post-Pliocene beds laid open at the marble quarries of Kilkenny, shown to me this summer by Mr. Hardman, of the Geological Survey. This and other sections in the district tend to prove that the Upper Boulder-clay occupies a considerable extent of surface in that part of Ireland. As this fine section will probably be described in detail by Mr. Hardman himself, I shall not further allude to it, than to say that it puts out of court any future attempts to call in question the succession of the Drift series as given above.

The "Esker Drift" so-called, I consider to be later than the Upper Boulder-clay, and is only a remodelled form of the true Drift-beds.

5, Raglan Road, Dublin, 10 *Sept.* 1875. Edward Hull.

MR. BONNEY ON GLACIAL EROSION.

Sir,—On this subject, in this month's Number, Mr. Bonney is as full of sound sense as usual. But as regards the *widening* of upland valleys I wish that I could persuade him that there is no necessity for "the volume of the stream being formerly greater," or for "the slow motion of the river from one side of the valley to the other," and to substitute "atmospheric and rain erosion" for "fluviatile erosion." I never heard of what Mr. Goodchild calls "the spring theory" for forming cliffs and *widening* valleys. He indeed controverts the theory, in which I most cordially agree with him. But does any one hold it? If so, who? Springs cut channels, but what *widens* these channels into valleys is atmospheric disintegration and the erosion of rain. For this reason the same valley is always narrow directly as the hardness of the strata and wide directly as its softness. So in rocky strata cliffs and rock ledges will be formed; in soft strata smooth sloping sides; but if the widening of valleys resulted, as Mr. Goodchild says, from "mechanical means," the soft strata should form cliffs and ledges as well as the hard ones.

Brookwood Park, Alresford, George Greenwood, Colonel.
15th September, 1875.

Geological Survey of India.—We are glad to be able to announce the promotion of Mr. King to the first grade of this department, and of Messrs. Hughes and Willson (the latter formerly of the Geological Survey of Ireland) to the second grade. We are also glad to see that Dr. W. Waagen has succeeded to the separate appointment of Palæontologist left vacant by the lamented death of Dr. Stoliczka. With Dr. Waagen and the recent additions to the staff of Mr. R. Lydekker and Dr. O. Feistmantel, the Indian Survey may be congratulated upon its great palæontological strength.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE II. VOL. II.

No. XI.—NOVEMBER, 1875.

ORIGINAL ARTICLES.

I.—On the Former Climate of the Polar Regions.[1]

By Prof. A. E. Nordenskiöld, For. Corr. Geol. Soc. Lond., etc., etc.

ONLY a few years ago it was looked upon as an article of faith among geologists, that the whole globe was once in a melted incandescent state, and that the conditions of temperature now prevailing on the surface of the earth have been in process of time produced by the slow gradual cooling of the once fused and glowing mass. It then appeared so natural that, in consequence of the earth's internal heat, a tropical climate should extend from pole to pole, that no special weight was attached to the evidences of this fact which geology was at that time able to produce. The Dane Giesecke's and the English Scoresby's specimens of fossil plants from the east and west coasts of Greenland, evidencing a warm climate there, attracted so little attention, that neither they, nor the fossil remains of Saurians found by the famous Arctic traveller Sir Edward Belcher in the American Polar Archipelago, could be found in the museums to which they had been confided.

It was not till geologists had become fully convinced that the gradual transition from the time when a warm climate was supposed to have prevailed over the whole earth and the present time has at least once been interrupted by a period during which the greater part of the European and American continents were covered by mighty glaciers, that the geological theory of climates was taken up with real interest. People began gradually to perceive that, even supposing the earth really to have once been in a state of glowing fusion, the cooling must already at the Cambrian and Silurian epochs have proceeded so far that the quantity of heat which the earth lost by radiation was fully compensated by that which it received from the other heavenly bodies. It has also been supposed that the cause of the Glacial period—when vast ice mountains scattered boulders from Scandinavia over the plains of Northern Germany, and when the Swiss Alps formed the centre of an icy desert similar to the present Greenland—is to be sought for in some trifling changes in the form of the earth's orbit and the inclination of the Equator, which have taken place, and continue to take place, periodically after the lapse of thousands or hundreds of thousands of years. The same causes which have once produced the Glacial

[1] A Lecture delivered at the Anniversary Meeting of the Royal Swedish Academy of Science, March 31, 1875.

period have thus happened, not only during this last period nearer to our own time, but also many times before; and there is reason to suppose that they were also then followed by somewhat similar results,—that is to say, that the cold and the warm eras have many times alternated on the surface of the earth. In consequence of this, it has become a matter of the utmost importance to science to obtain by real observation accurate information as to the state of temperature on the earth's surface during as many of the different geological periods as possible. When in our days a scientific question is seriously propounded, it is seldom long before it is answered; and even in the instance before us we have of late years received numerous contributions to geological climatology from lands the geographical situation of which in the neighbourhood of the Pole renders them best fitted to yield information of this kind.

The geology of the polar tracts can in two different ways supply us with information concerning the former climate, partly by a comparison of the fossil animals and plants there found with existing forms that live under certain determinate climatic conditions, partly by an accurate examination of the various strata of different geological ages, with a view to ascertain whether these present any of the indications which usually distinguish Glacial formations.

We now possess fossil remains from the polar regions belonging to almost all the periods into which the geologist has divided the history of the earth. The Silurian fossils which McClintock brought home from the American Polar Archipelago, and the German naturalists from Novaja Semlja, as also some probably Devonian remains of fish found by the Swedish Expeditions on the coasts of Spitzbergen, are, however, too few in number, and belong to forms too far removed from those now living, to furnish any sure information relative to the climate in which they have lived.

Immediately after the termination of the Devonian age, an extensive continent seems to have been formed in the polar basin north of Europe, and we still find in Beeren Island and Spitzbergen vast strata of slate, sandstone, and coal, belonging to that period, in which are imbedded abundant remains of a luxuriant vegetation, which, as well as several of the fossil plant-remains brought from the polar regions by the Swedish Expeditions, have been examined and described by Prof Heer of Zürich. We here certainly meet with forms, vast *Sigillaria*, *Calamites*, and species of *Lepidodendra*, etc., which have no exactly corresponding representatives in the now existing plants. Colossal and luxuriant forms of vegetation, however, indicate a climate highly favourable to vegetable development. A careful examination of the petrifactions taken from these strata shows also so accurate an agreement with the fossil plants of the same period found in many parts of the Continent of Central Europe, that we are obliged to conclude that at that time no appreciable difference of climate existed on the face of the earth, but that a uniform climate extremely favourable for vegetation—but not on that account necessarily tropical—prevailed from the Equator to the Poles.

The sand and slate beds here mentioned do not contain any marine petrifactions, whence we may conclude that they have been formed in lakes or other hollows in an extensive polar continent. In Beeren Island and Spitzbergen they are, however, covered by beds of limestone and siliceous rock, which form the chief material in Beeren Island, and of several considerable mountains on the southern side of Hinloopen Strait, and the innermost bays of Ice-fjord in Spitzbergen. The manner in which these mountains rise several thousand feet above the surrounding snow desert, their regular form, crowned with vast masses of dark volcanic rock divided into vertical columns, the siliceous strata forming perpendicularly-scarped terraces, and the tendency of the calcareous beds to fall away and form natural arches, give to these mountains the appearance of ruins of colossal ancient fortifications and temples, unequalled in sublime and desolate magnificence. Here, indeed, we meet with the monumental gravestone of a long-past age. The rock is in fact formed almost entirely of shells of marine mollusca, fragments of Corals and Bryozoa of the age of the Mountain-limestone. We have then here not only a proof that the ancient polar continent sank down again and gave place to a deep polar ocean, but also, in the correspondence of the corals, shells, and other associated organic remains, with those met with in more southerly tracts, an indication that the warm polar climate remained unchanged.

The Mountain-limestone period was followed by an era during which the richest coal-beds of England, Belgium, and America were formed, and which has accordingly received the name of the Coal period. A new distribution of land and water had now taken place, continents had again arisen in the polar tracts, in the sandstones and argillaceous strata of which we again find, at Bell-sound, on the western coast of Spitzbergen, fossil plants that bear witness to a rich polar vegetation developed under a warm climate. Among these, however, we miss the species of large-leaved fern so abundant in the coal-beds of more southerly lands, a circumstance which may possibly indicate a certain difference of climate as existing at that epoch, unless, as is more probable, the circumstance is merely the result of the insufficiency of the materials brought from but one single arctic locality.

The only relics from the polar regions belonging to the succeeding era, the Triassic, are those of marine animals, amongst which a considerable portion consists of large shell-clad Cephalopoda related to Ammonites, Nautilus, etc., which, judging from the habits of the forms still existing in our time, could assuredly only live in a warm ocean. More certain information relative to the nature of the polar climate at that time is afforded by portions of skeletons of colossal Sauria—one form, *Ichthyosaurus polaris*, seems to have reached a length of 20 or 30 feet—which, together with vast coprolite beds, are found in great abundance inclosed in the Triassic strata of Ice-fjord, and which among the now existing fauna have their nearest representatives in the crocodiles on the sunny banks of the Nile, or perhaps rather in the marine lizard *Amblyrhynchus* met with in the Galapagos Isles. That multitudes of these coldblooded animals lived at that time in the vicinity of the 80th degree of latitude attests beyond all doubt climatal conditions very different from that of the present day.

At the entrance of Ice-fjord and at Mount Agardh, in Stor-fjord, the Triassic strata are covered with marine formations belonging to the immediately subsequent geological era, the Jura period, and, as far as we can judge from the few fossil remains hitherto discovered in these strata, no diminution had as yet taken place in the warmth of the polar climate. But great changes now came to pass in the portion of the polar basin north of Europe, the ocean being again transformed into a continent, which, though shattered and reduced, still exists up to the present time. The upper portion, therefore, of the Jura formation of Spitzbergen does not contain any marine organisms, but in the place of them beds of sandstone and slate, with coal-seams and impressions of plants. From the strata belonging to that age met with at Cape Boheman in Ice-fjord, situated between the 78th and 79th degrees of latitude, the Swedish Expeditions have brought home numerous impressions of palm-like Cycadeæ and Coniferæ, the representative species of which now flourish in the neighbourhood of the tropics. This already leads to the supposition of a warm climate, which supposition is further confirmed by a comparison with the European fossil flora of the same date, which indicates that the climate of Spitzbergen did not then materially differ from that of Central Europe.

The Swedish Expeditions have also succeeded in obtaining, partly from Greenland and partly from Spitzbergen, from two separate epochs of the Cretaceous era, extensive collections of fossil plants, lately described by Prof. Heer in the Transactions of the R. Swedish Academy. By this we have been enabled not only to determine the epoch when differences of climate first begin to show themselves on the surface of the earth, but also pretty closely to follow an extremely remarkable change in the appearance of the vegetable world which took place during the course of that period.

Within the polar basin we meet with the lowest division of the Cretaceous age on the north side of the Noursoak Peninsula, in North-Western Greenland. The crown of the hills is here composed of black, ancient lava-streams and immense beds of volcanic tuff, hardened in process of time into solid rock.

Over these volcanic formations now rests a covering of perpetual ice, and beneath them on the sea-shore vast strata of sand are discovered, containing inconsiderable Coal-beds, interstratified with clay-beds and a fine-grained argillaceous shale singularly fitted for preserving the impressions of fossils that have been imbedded in it. These plants belong to the lowest portion of the Cretaceous age, and among the collections brought from this spot Heer has succeeded in distinguishing 75 different species, among which are 30 Ferns, 9 Cycadeæ, and 17 Coniferæ.

The third part of the Ferns belongs to one genus, *Gleichenia*, which still flourishes in the neighbourhood of the tropics and warmer parts of the temperate zone, and the same remark holds good of the

Cycadeæ, most of which are referable to the genus *Zamia*, species of which we meet with within the tropics, as also of the Coniferæ, some of which are nearly related to forms still existing in Florida, Japan, and California. From this Heer draws the conclusion, that in the early part of the Cretaceous period the climate of the now ice-covered Greenland was somewhat like that which now prevails in Egypt and the Canary Isles.

Among the Ferns, Cycadeæ, and Coniferæ of Noursoak peninsula were found a few impressions of a species of Poplar, *Populus primæva*, which formed the only, and at the same time the oldest known representative of the forest vegetation now prevailing in the temperate zone. Nevertheless the vegetation of the arctic tracts was already during the Cretaceous period undergoing a complete transformation. Evidence of this has been obtained from the same locality, Atanekerdluk, on the south side of the Noursoak peninsula, from which such magnificent remains of arctic vegetation of the Tertiary period had previously been obtained, from strata at a somewhat higher level. Here, out of the talus that has fallen from the lofty fells, some black and tolerably easily crumbling strata of shale protrude, among which, on careful inspection, impressions of plants may be discovered belonging to the Cretaceous formation, not to the lower, but the upper portion of it. The vegetation is here quite different. The Ferns and Cycadeæ have disappeared, and in their place we find deciduous trees and other dicotyledons in astonishing variety, and forms, among which a species of fig may be mentioned, of which not only the leaves, but also the fruit have been obtained in a fossil state; two species of Magnolia, etc. The climate that then prevailed over the whole globe was therefore still warm and luxuriant, even if, at least in the Arctic regions, considerably modified from what it formerly had been, inasmuch as that the flowerless vegetation (which was now beginning to die out), as far as we can judge from its present representatives, the ferns, required a warm humid climate, whereas the new forms, with their luxuriant flowers, which now began to characterize the vegetable world, required, in order to develope all the grandeur of their colours, a clear and sunny sky. The disappearance of sundry tropical and sub-tropical forms, that are met with in the older Cretaceous strata, has led Heer to the conclusion that difference of climate at different latitudes was now beginning to show itself, and he calls attention to the circumstance that this takes place synchronously with the development of the dicotyledonous plants in greater variety.

Unhappily, in the Arctic regions no fossil remains belonging to the Eocene age, which immediately succeeded the Cretaceous period, have hitherto been met with, and we are therefore destitute of the actual data necessary for ascertaining its climatic character. But the next following, or Miocene age, places at our disposal abundant materials in the magnificent remains of plants obtained, we may say, from all parts of the polar basin and its vicinity; from West Greenland by Inglefield, McClintock, Rink, Torell, Whymper, and the Swedish Expeditions; from East Greenland by Payer; from Alaska by Mr. Furnhjelm; from Sagalin by Admiral Furnhjelm; and from different localities of Spitzbergen by the Swedish Expeditions.[1] The spots where remains of this period are found are frequently distinguished by their astonishing abundance of fossil plant-remains.

For example, at a place in Spitzbergen which we have called Cape Lyell, after the lately-deceased great English geologist, the rocks on the shore for a distance of several hundred feet form a continuous herbarium, where every stroke of the hammer brings to light an image of the vegetation of a long-past age—when the forest vegetation of these tracts consisted of the swamp-cypress of Texas (*Taxodium distichum*), of gigantic Sequoias, relations or ancestors of California's mammoth-tree, of large-leafed birches, limes, oaks, beeches, planes, and even magnolias. The place is situated in about 77° 35′ N. lat., on the south side of the entrance to Bell-sound, on the western coast of Spitzbergen. At the foot of the cliff, on one or two barren heaps of gravel, one may discover shoots of an inch long of the polar willow, sole representative of the present vegetation of the locality. Just off the shore the ocean currents drive icebergs, which have fallen from the neighbouring glaciers, backwards and forwards, and the crown of the rock itself forms the limit of a mighty glacier, which threatens within a few years to bury under an icy covering of several hundred feet thickness not only the little vegetation that exists here, and which in the summer weeks is sometimes adorned with charming colours, but also the memorials of the ancient glorious age now preserved within its rocks.

By a careful examination of the rich materials here accessible, and by a comparison of the petrifactions with those of the same period found in more southerly localities, Heer has shown that already in the Miocene era considerable variety of climate existed on the face of the earth, though even the Pole at that time enjoyed a climate fully comparable with that of Central Europe now. The then Flora of Europe had almost entirely an American character, and there are many reasons for supposing that the continents of Europe and America were at that time united, and bounded on the south by an ocean extending from the Atlantic over the present deserts of Sahara and Central Asia to the Pacific.

Between the Miocene and the present eras are two important periods, the Pliocene and the Glacial, which to us are particularly deserving of attention, inasmuch as that during them man, the lord of creation, seems first to have made his appearance. That during the latter of these periods vast masses of ice covered at least all the northern part of Europe is a well-known fact; but concerning the nature of the transition from the glorious climate of the Miocene age to the Glacial period, we possess no knowledge whatever founded on actual observation. Probably at some future time contributions towards the solution of this important question may be

[1] We may also mention the evidence of an Arctic Miocene Flora obtained by Sir John Richardson from fine indurated clay-beds, associated with Coal-seams, on the Mackenzie River, near Great Bear Lake, from which 17 species of fossil plants have been identified by Heer.—Edit. Geol. Mag.

found amongst the mountain masses that occupy the peninsula between Ice-fjord and Bell-sound in Spitzbergen, or in some parts of the basalt region of north-western Greenland. In the interior of Ice-fjord and at several other places on the coast of Spitzbergen, one meets with indications either that the polar tracts were less completely covered with ice during the Glacial era than is usually supposed, or that, in conformity with what has been observed in Switzerland, inter-glacial periods have also occurred in the polar regions. In some sand-beds not very much raised above the level of the sea one may in fact find the large shells of a mussel (*Mytilus edulis*) still living in the waters encircling the Scandinavian coast. It is now no longer found in the sea around Spitzbergen, having been probably rooted out by the ice-masses constantly driven by the ocean currents along the coasts.

From what has been already stated, it appears that the animal and vegetable relics found in the polar regions imbedded in strata deposited in widely separated geological eras uniformly testify that a warm climate has in former times prevailed over the whole globe. *From Palæontological science no support can be obtained for the assumption of a periodical alternation of warm and cold climates on the surface of the earth.*

A careful investigation of the structure of the different sedimentary strata leads to the same result. We are now very well acquainted with the origin and nature of the various strata, the substance of which has been supplied by the destructive operation of glaciers on the surrounding and subjacent mountain masses, and we can point out certain marks by which these strata may be distinguished from other non-glacial deposits. In these last, one very rarely meets with any large stone boulders, which have fallen from some neighbouring cliff, and been imbedded in sand or clay, either directly, and, if so, close to the place where originally found, or else after having in the spring been moved a greater or less distance by river ice. In glacial formations, on the contrary, as one may gather from the study of the strata in Scandinavia that belong to the glacial period, erratic blocks transported on icebergs to far-distant regions play an important part. If a climate similar to that which now prevails in the arctic regions has several times during various geological eras existed in the neighbourhood of the Pole, one has reason to expect that sandstones inclosing large boulders should often be met with in these tracts.

But this is by no means the case, though such formations, if they exist on a large scale, could hardly escape observation.

The character of the coasts in the Arctic regions is especially favourable to geological investigations. While the valleys are for the most part filled with ice, the sides of the mountains in summer, even in the 80th degree of latitude, and to a height of 1000 or 1500 ft. above the level of the sea, are almost wholly free from snow. Nor are the rocks covered with any amount of vegetation worth mentioning, and, moreover, the sides of the mountains on the shore itself frequently present perpendicular sections, which everywhere expose their bare surfaces to the investigator. The knowledge of a mountain's geognostic character, at which one in more southerly countries can only arrive after long and laborious researches, removal of soil and the like, is here gained almost at the first glance; and as we have never seen in Spitzbergen nor in Greenland, in these sections often many miles in length, and including, one may say, all formations from the Silurian to the Tertiary, any boulders even as large as a child's head, there is not the smallest probability that strata of any considerable extent, containing boulders, are to be found in the Polar tracts previously to the middle of the Tertiary period.

Since, then, both an examination of the geognostic condition, and an investigation of the fossil flora and fauna of the polar lands, show no signs of a Glacial era having existed in those parts before the termination of the Miocene period, we are fully justified in rejecting, on the evidence of actual observation, the hypotheses founded on purely theoretical speculations, which assume the many times repeated alternation of warm and glacial climates between the present time and the earliest geological ages.

II.—On some Fossil Foraminifera from the West-Coast District, Sumatra.

By Henry B. Brady, F.R.S., F.L.S., etc.

(PLATES XIII. and XIV.)

NOTE.—The Fossils about to be described were sent to England in 1873 and 1874 by Heer R. D. M. Verbeek, Director of the Geological Survey of Sumatra, and are here published by the authority and with the aid of the Dutch-Indian Government.

A general account of the geology of the West-Coast District of Sumatra, by Heer Verbeek, is given in the Geological Magazine for October, 1875, New Series, Vol. II. pp. 477–486.

T. Rupert Jones.

The series of fossil Foraminifera, collected by Heer Verbeek in Sumatra, to which the following paper refers, were placed in my hands by my friend Prof. T. Rupert Jones, F.R.S., F.G.S., for examination and description. Doubtful points in connexion with them—for many of the specimens are more or less obscure—have been determined after joint deliberation, and the views stated throughout have been corroborated by my friend and collaborateur.

1. Operculina granulosa, Leymerie. Pl. XIII. Figs. 1, *a*, *b*, *c*.

Operculina granulosa, Leymerie, 1846, Mém. Soc. géol. France, 2 sér. vol. i. Mém., No. 8, p. 359, pl. 13, figs. 12 *a*, *b*, *c*.

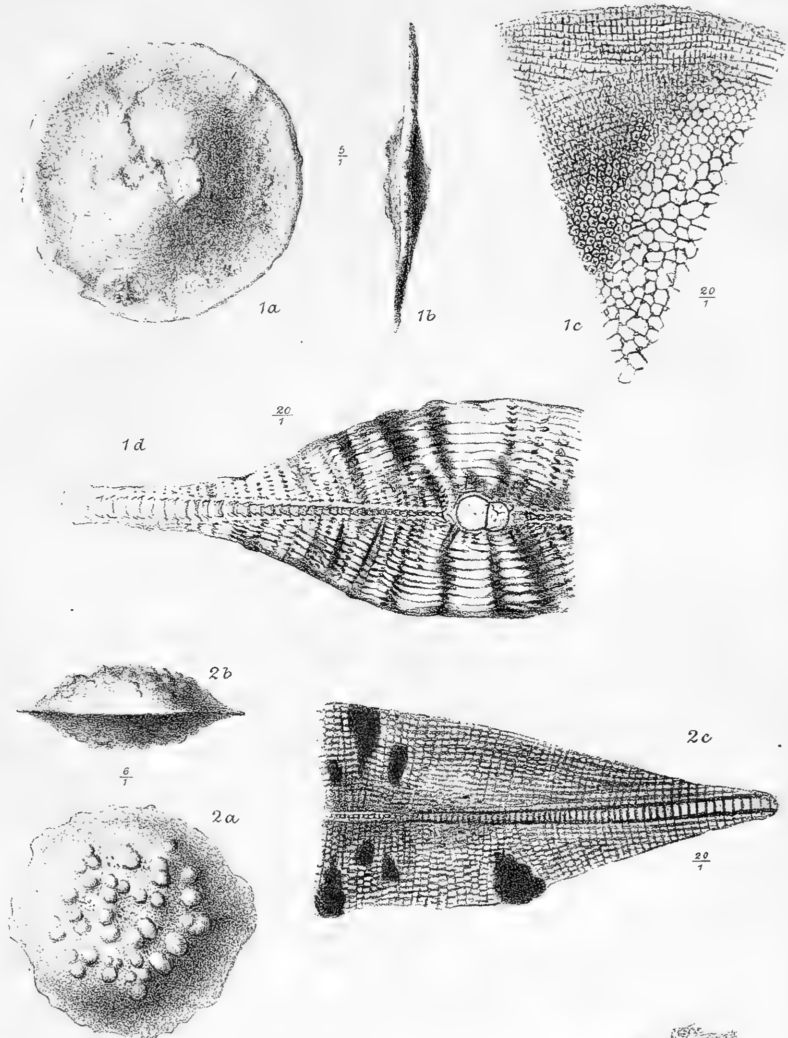
[*Assilina undata*, D'Orbigny, 1826, Ann. Sci. Nat. vii. p. 296, No. 3.

Assilina undata, 1850, Prodrome de Paléont. vol. ii. p. 336, No. 684; *fide* D'Archiac, "Descr. Anim. foss. Groupe numm. de l'Inde," p. 157.]

Amongst Heer Verbeek's fossil Foraminifera from Sumatra, the

A.T. Hollick del. et lith. W. West & Co. imp.

Fossil Foraminifera from Sumatra



A.T. Hollick del et lith. W. West & Co. imp.

Fossil Foraminifera from Sumatra.

most fully represented excepting *Orbitoides*, as far as number of specimens goes, is the genus *Operculina*. The *Operculinæ* are in two sets, the more numerous series, containing also the finer examples, from the Coralline Limestone of Nias Island; the smaller one from the West Coast of Sumatra. Of the larger examples, Figs. 1, *a*, *b*, *c*, Plate XIII. are fairly representative. They may be assigned without hesitation to *Operculina granulosa*, Leymerie, a variety differing from the typical *O. complanata*, Defrance, not only in its more or less granulate or beaded surface, but in the slower and more gradual increase in breadth of the spiral band of chambers. The specimens of the less numerous set are smaller in size, and their characters are much less strongly marked. They bear some resemblance to the modification figured by Leymerie (*loc. cit.* fig. 11, *a*, *b*) under the name *O. ammonea;* but there can be little doubt that the differences in minor particulars are dependent on mere external circumstances either of life, or in the process of fossilization; at any rate there seems no substantial basis for their specific separation.

The finer specimens of *O. granulosa* from Nias Island have a diameter of $\frac{1}{5}$ inch (4·5 mm.), and consist of about five moderately broad convolutions, the individual chambers being very narrow and numerous. The primordial chamber is minute, as is commonly the case in the Operculine type; but there is considerable thickening of the shell-wall, especially near the centre, shown externally by a more or less prominent umbo.

Operculina granulosa is a well-known species occurring in the earlier Tertiary beds of Europe in company with fossil *Nummulinæ*.

Localities—The precise habitats of these Eastern specimens of *Operculina* are the Tertiary Limestone of Nias Island, where they are found in company with Corals and Nummulites, and the Marl-sandstone, of an earlier Tertiary age, in the Padang Highlands on the West Coast of Sumatra.

2. NUMMULINA VARIOLARIA (Sowerby). Pl. XIII. Figs. 2, *a*, *b*, *c*, 3, *a*, *b*, *c*.

Nummularia variolaria, Sowerby, 1829, Mineral Conchology, vol. vi. p. 76, pl. 838, fig. 3.

Nummulites variolaria, D'Archiac et Haime, 1853, Descr. Anim. foss. Groupe numm. de l'Inde, p. 146, pl. 9, figs. 13, *a*—*g*.

A set of minute Nummulites (labelled "small"), of which Figs. 2, *a*, *b*, *c*, are examples, and another series (marked "middle-sized") represented by Figs. 3, *a*, *b*, *c*, may both be assigned to the same species—*N. variolaria*. The smaller ones are about $\frac{1}{25}$ inch (1· mm.) in diameter, and consist of about three convolutions, of which the third possesses, on the average, sixteen chambers. The primordial chamber is $\frac{1}{250}$ inch (0·1 mm.) in diameter. The larger specimens average about $\frac{1}{12}$ inch (2·0 mm.) in diameter, and have four or more convolutions, the outermost composed of about nineteen segments; the primordial chamber is of the same size as in the smaller ones. The proportionate thickness is much the same in the two cases, save that the larger specimens are often rather umbonate. It will be seen, therefore, that there is no distinction, of even varietal force, to be drawn between the two; and they correspond sufficiently closely with the description and figures of *N. variolaria* given by MM. D'Archiac and Haime. It is needless to enter into detailed examination of any species which has been treated by the authors referred to in their exhaustive way, or indeed to do more than observe, in general terms, that the form under consideration is one of the "radiate" group,[1] comprising the small and relatively thick modifications of *Nummulina planulata*, common in the early Tertiaries of Western Europe.

Locality—Coralline Limestone of Nias Island.

3. NUMMULINA RAMONDI, Defrance. Pl. XIII. Figs. 4, *a*, *b*.

Nummulites Ramondi, Defrance, 1825, Dict. des Sci. nat. vol. xxv. p. 224.

Nummulites Ramondi, D'Archiac et Haime, 1853, Descript. Anim. foss. Groupe numm. de l'Inde, p. 128, pl. 7, figs. 13–17.

To this species may safely be assigned a small number of somewhat obscure radiato-striate Nummulites from Nias Island, one of which is represented in Pl. XIII. Figs. 4, *a*, *b*. The largest specimen has a diameter of $\frac{1}{8}$ inch (3·0 mm.), and is about $\frac{1}{20}$ inch (1·2 mm.) in thickness. It has been difficult to arrive at any exact information as to the interior structure of the specimens, as in all of those of which microscopical sections have been attempted, not only the minute anatomy of the shell, but even the septation, was greatly obscured by subcrystalline infiltration. None of those examined had more than about six convolutions, the outermost formed of about fifty chambers—being therefore somewhat smaller than the dimensions of *N. Ramondi* as set down by Messrs. D'Archiac and Haime, that is, so far as the examples sent to us are representative—but in all important characters they correspond fairly with the description and figures of the French monograph. Externally they are radiato-striate; in the horizontal section the spiral wall is much thicker than the septal lines; the number of chambers corresponds sufficiently closely, though the number of convolutions is not so great, and the primordial chamber is, as far as can be made out, relatively small. The specimen figured shows considerable want of symmetry in its peripheral aspect, the two sides being of unequal convexity, a rather unusual feature in *Nummulina.* This form is not far removed zoologically from the Bornean specimens which Heer Verbeek has described under the name *Num. Pengaronensis*,[2] and which are rightly supposed by him to be near allies of *N. Ramondi;* but we find nothing in the material at our command to suggest the necessity of separating the Sumatran examples from the latter species.

Few of the Nummulites have a wider distribution than this; from the south-west of France, eastwards through Central Europe,

[1] See Ann. Nat. Hist. ser. 3, vol. v. p. 110, and viii. p. 231.

[2] Neues Jahrbuch für Min., etc., Jahrgang 1871, p. 3, pl. 1, figs. 1, *a–k*.

North Africa and Asia; indeed almost wherever the early Tertiary Nummulitic strata appear, *N. Ramondi* seems to be present.

Locality—The Nias Limestone, of late Tertiary age, with Nummulites and Corals.

4. Nummulina Ramondi, var. Verbeekiana, *nov.* Pl. XIII. Figs. 5, *a*, *b*, *c*.

In the collection of Nummulites are a few examples somewhat smaller than the foregoing, also from the Tertiary limestone of the Island of Nias. In general external characters they are very similar to *N. Ramondi,* but they differ considerably in interior structure. The best specimen is that figured in Pl. XIII. Fig. 5, *a;* but the drawing, though accurate up to the magnifying power employed, is a little ambiguous. By the abrasion of the outer laminæ in places, an appearance like that of the lobulate segments of *Amphistegina* is produced; the fact being that the septal lines of some of the inner convolutions are laid bare near the periphery, and these happen to be set more obliquely than those of the outermost whorl, so that the latter appear in the drawing to be suddenly reflexed at a short distance from the margin. The radiating septal lines, however, are in reality not continuous, as they appear in the figure; and with a higher magnifying power and carefully adjusted light the portions near the periphery—that is, the oblique or reflexed ends of the radii—are seen to belong to the penultimate or even an earlier convolution. The horizontal section, Fig. 5 *b*, is clearly the section of a Nummulite, not of an *Amphistegina.*

The distinctions between this variety and what may be regarded as the typical *N. Ramondi* consist, firstly, in the smaller number of segments in each convolution, and, secondly, in their greater obliquity and curvature. The largest specimen has a diameter of about $\frac{1}{11}$ inch (2·5 mm.), and is somewhat thick and umbonate. Average examples appear to have from five to six convolutions; the sixth with about twenty-six segments. It has been found impossible to ascertain accurately anything about the primordial chamber, all the central portions of the tests being obscured by the obliterating nature of the mineral infiltration.

Under the circumstances we can perhaps scarcely do better than distinguish the Nummulite under notice as a variety, naming it *Verbeekiana,* after Heer Verbeek.

Locality—Coralline Limestone of Nias Island.

5. Orbitoides papyracea (Boubée). Pl. XIV. Figs. 1, *a*, *b*, *c*, *d*.

Nummulites papyracea, Boubée, 1832, Bull. Soc. géol. France, vol. ii. p. 445.

Orbitolites Pratti, Michelin, 1840–1847, Icon. zooph. p. 278, pl. 63, fig. 14.

Orbitolites Fortisii, D'Archiac, 1850, Hist. Progr. Géol. vol. iii. p. 230.—Mém. Soc. géol. France, 2 sér. vol. v. p. 404, pl. 8, figs. 10–12.

Orbitoides papyracea, Gümbel, 1868, Abh. d. II. Cl. Akad. Wissensch. München, vol. x. pt. 2, p. 690, pl. 3, fig. 1.

The nomenclature of this species, better known to English palæontologists as *Orbitoides Pratti* and *O. Fortisii,* has been worked out with great minuteness by Dr. Gümbel, and to his paper on the North-Alpine Eocene Foraminifera (*op. cit.*), from which the above references are taken, the reader may be directed for its full synonymy.

The Sumatran specimens call for but little comment. Their general external appearance is shown in Pl. XIV. Figs. 1, *a, b*; the nearly median horizontal section is given in Fig. 1 *c*, and the transverse section in Fig. *d*. The largest of Heer Verbeek's examples has a diameter of $\frac{6}{10}$ of an inch (15 mm.), and a thickness, at the centre, of about $\frac{1}{8}$ inch (3·5 mm.); but most of them are proportionately thinner than the above fractions indicate, and as very few of them attain even these dimensions, they may be regarded as somewhat small examples of the species. Figs. *a* and *b* represent fair average specimens, magnified five diameters; the drawings of internal structure, *c* and *d*, are on a higher scale, namely 20 diameters.

Locality—Coral-limestone, Padang Highlands, West-Coast District, Sumatra.

6. Orbitoides dispansa (Sowerby). Pl. XIV. Figs. 2, *a, b, c.*

Lycophris dispansus, J. de C. Sowerby, 1836, Trans. Geol. Soc., 2 ser. vol. v. p. 327, pl. 24, figs. 15, 16.

Lycophris (*Orbitoides*) *dispansus,* Carter, 1853, Journ. Bombay Asiat. Soc., vol. v. p. 126, pl. 2, figs. 23–29.

Orbitoides dispansa, D'Arch. et Haime, 1854, Descr. An. foss. Groupe numm. de l'Inde, p. 349.

Orbitoides dispansa, Gümbel, 1868, Abh. d. II. Cl. Akad. Wissensch. München, vol. x. pt. 2, p. 701, pl. 3, figs. 40–47.

A few specimens of a small, thick, lenticular *Orbitoides,* with tuberculate surface (Pl. XIV. Figs. 2, *a, b, c*), may with confidence be assigned to *O. dispansa,* a species best known as one of the important fossil constituents of the Tertiary rocks of Scinde, and more recently found in the Eocene beds of southern Germany and of Italy.

Heer Verbeek's specimens are small; somewhat less than $\frac{1}{4}$ inch (6 mm.) in diameter, and $\frac{1}{12}$ inch (2 mm.) in thickness. Many of them have both surfaces not merely granulate, which is a common condition, but studded with large prominent tubercles, as shown in the figure. Beyond this they seem to offer no points of peculiarity; but the specimens altogether present much greater variety of external contour than those of *O. papyracea.*

Localities—Orbitoidal Limestone, Bockit Poangang, Sumatra, and the Marl-rock of Nias Island.

7. Orbitoides Sumatrensis, *sp. nov.* Pl. XIV. Figs. 3, *a, b, c.*

There are still some two or three little fossils pertaining to the genus *Orbitoides,* very different in shape and proportionate dimensions from either of the foregoing. One of these is represented in Pl. XIV. Figs. 3, *a, b*. They are sub-globular or only slightly compressed, one-eighth of an inch (3· mm.) in diameter, and about one-tenth of an inch (2·5 mm.) in thickness. The exterior is rough and granular. Laid horizontally, there is an irregular, partial extension of the periphery, which seems to suggest an abortive disc. It is within the bounds of possibility that these specimens may be the central thick portions of some form like the more umbonate varieties of *O. dispansa*, but the interior structure does not lend itself to this supposition. The general arrangement of the chamberlets is shown in Fig. 3 *c*, which is drawn from a horizontal section near, but not at, the median plane. A transverse section shows the median disc, which does not appear to be quite uniformly central in its position, exceedingly thin in the middle, thickening rapidly towards the circumference, rounded at the margin, and having somewhat the contour, in section, of an hour-glass drawn out a little at the ends. The primordial chamber, as far as can be made out, is very small. Such structural and morphological peculiarities as these do not seem to be in accord with the characters of any published species; and, notwithstanding a certain amount of doubt, in the absence of sufficient material for complete investigation, as to the degree of relationship that may exist between these sub-globular specimens and *O. dispansa*, we have but little hesitation in concluding that they represent an undescribed form, and have named them accordingly.

Locality—Marl-rock of Nias Island, West Coast of Sumatra.

8. Fusulina princeps (Ehrenberg). Pl. XIII. Figs. 6, *a–c*.

Borelis princeps, Ehrenb., 1854, Mikrogeologie, pl. xxxvii. figs. x. c, 1–4. See also Monatsberichte d. k. Akad. Berlin, für 1842, p. 273, and 1843, p. 106.

Fusulina princeps, Parker and Jones, 1872, Annals N. Hist. ser. 4, vol. x. pp. 257 and 260.

The genus *Fusulina* is of extreme interest to both the Geologist and the Zoologist,—to the former on account of its restricted stratigraphical range and from the important part it has played as a rock-builder; to the latter from its isomorphism with two other remarkable genera of Foraminifera, namely *Alveolina* in the "porcellanous," and *Loftusia* in the "arenaceous" series. The specimens sent by Heer Verbeek are of considerable scientific value, giving us the morphological parallel to some of the *Alveolinæ* of the Tertiary limestones of Central Europe and Western Asia.

The fossils figured by Prof. Ehrenberg under the name *Borelis princeps* are from the "Hornstone of the Mountain-limestone of the Pinega (Dwina), Archangel." They are much inferior in point of size to those collected by Heer Verbeek, but otherwise the resemblance in morphological characters is sufficiently close, and the specific name "princeps" acquires a fresh significance as applied to the Sumatran fossils. The dimensions given in the "Mikrogeologie" are $\frac{1}{6}$ of an inch (4·0 mm.), by about $\frac{1}{8}$ inch (3·0 mm.). Heer Verbeek's specimens vary considerably in size, the largest being $\frac{9}{20}$ of an inch (11 mm.) long, by $\frac{4}{10}$ in. (10 mm.) broad; the smallest $\frac{1}{5}$ in. (5 mm.) long, by $\frac{1}{6}$ in. (4 mm.) broad; but many of the smaller ones are manifestly incomplete, being in reality the central portions of larger specimens, of which the outer whorls have been broken away, the fracture following the course of the spiral lamina. The largest number of convolutions traced in any one transverse section is eleven. In their lateral aspect all the larger examples are broadly elliptical, the conjugate diameter being about one-tenth longer than the transverse. The depressions marking the longitudinal septa are pretty evenly distanced, but the individual boundary-lines are somewhat irregular in their course. The colour of some of the specimens is nearly white, of others dark-grey.

Perhaps the most nearly allied variety of *Fusulina* to that under notice is the *F. sphærica* of Dr. Herrman Abich,[1] found in the Mountain-limestone of Armenia and Azerbeidjan. I am indebted to Dr. Abich for examples of this interesting form, which is correctly represented in his published drawing as an oblate or somewhat drum-shaped organism, not prolate or elliptical like the Sumatran specimens.

On the other hand, we have a near connexion of *F. princeps* in *Fusulina robusta*, described by Dr. Meek[2] from Californian specimens; but the pointed ends of the latter seem to indicate a much closer relationship to the type *F. cylindrica*, with which it is also associated in distribution.

In speaking of *Fusulina* as an essentially Carboniferous genus, the stratigraphical term must be taken to include those Upper Carboniferous beds termed "Permian" by American geologists; indeed, the very largest recorded examples of the type are those described by Shumard[3] under the name *F. elongata*, some of which are stated to be two inches (5 centim.) in length. They were found in the Permian Limestones of New Mexico and Texas.

Locality — Carboniferous Limestone, Padang Highlands, West Coast of Sumatra.

EXPLANATION OF THE PLATES.

Plate XIII.

Fig. 1.—*Operculina granulosa*, Leymerie. All the figures magnified 8 diameters.
a. Lateral aspect. *b.* Periphero-lateral aspect. *c.* Interior, as shown by a split specimen.

Figs. 2 and 3.—*Nummulina variolaria* (Sowerby). All the figs. mag. 10 diam.
a. a. Lateral aspect. *b. b.* Periphero-lateral aspect. *c. c.* Interior, as shown by split specimens.

Fig. 4.—*Nummulina Ramondi*, Defrance. Both figures magnified 10 diameters.
a. Lateral aspect. *b.* Periphero-lateral aspect.

Fig. 5.—*Nummulina Ramondi*, var. *Verbeekiana*, nov.
a. Lateral aspect. Magnified 10 diameters.
b. Horizontal median section, showing septation. Magnified 28 diam.
c. Horizontal section near the exterior, showing the somewhat sinuate outline of the alar extension of the chambers. Magnified 28 diam.

Fig. 6.—*Fusulina princeps* (Ehrenberg). All the figures magnified 3 diam.
a. Lateral aspect. *b.* End aspect. *c.* Transverse section, showing septation.

[1] Mém. de l'Acad. Imp. Sci. St.-Pétersbourg, 1859, ser. 6, vol. vii. p. 528, pl. 3, figs. 13, *a*, *b*, *c*.

[2] Meek and Gabb, Geol. Survey of California; Palæontology, vol. i. 1864, p. 3, pl. 2, figs. 3, *a*, *b*, *c*.

[3] Trans. Acad. Sci. St.-Louis, 1858, vol. i. p. 297.

PLATE XIV.

FIG. 1.—*Orbitoides papyracea* (Boubée).
- *a*. Lateral aspect. Magnified 5 diameters.
- *b*. Periphero-lateral aspect. Ditto.
- *c*. Horizontal median section. Magnified 20 diameters.
- *d*. Central transverse section. Ditto.

FIG. 2.—*Orbitoides dispansa* (Sowerby).
- *a*. Lateral aspect. Magnified 6 diameters.
- *b*. Periphero-lateral aspect. Ditto.
- *c*. Central transverse section. Magnified 20 diameters.

FIG. 3.—*Orbitoides Sumatrensis*, sp. nov.
- *a*. Lateral aspect. Magnified 6 diameters.
- *b*. Periphero-lateral aspect. Ditto.
- *c*. Horizontal section, near the median plane. Magnified 35 diameters.

III.—ON THE LIMITS OF THE YOREDALE SERIES IN THE NORTH OF ENGLAND.[1]

By G. A. LEBOUR, F.G.S. London and Belgium, F.R.G.S., etc.
Lecturer on Geological Surveying at the University of Durham College of Physical Science, Newcastle-on-Tyne.

WHEN a group of beds has well-defined boundaries above and below, and when moreover its palæontological characteristics coincide with its stratigraphical limits, it becomes a boon alike to the field-geologist and to the fossil collector. When, on the other hand, both limits and fossils fail to enable one to follow a group beyond a certain point, the sooner the series as such is relegated to the limbo of purely-local, convenient, but untrue divisions, the better. I propose to show in this paper that the important group of beds commonly known as the Yoredale Series in the North-Western parts of Yorkshire is a group of the latter kind, convenient indeed in that district, but quite incapable of being traced much further North either stratigraphically or palæontologically.

I cannot find a more concise definition of what is usually meant by the term "Yoredale Series" than that given by my friend Prof. Nicholson.[2] He says: "The *Yoredale Series* of Phillips, the Upper Limestone or Limestone-shale series of some authors, consists of numerous alternating beds of limestone, sandstone, grit, and shale, with a few thin and worthless seams of coal, the whole attaining a thickness of 500 feet, according to Mr. Forster. The two most constant members of the Yoredale Series are the 'Tyne-bottom Limestone,' and the 'Main,' 'Great,' or 'Twelve-fathom' Limestone, respectively the lowest and the highest limestones of the group. As regards Cumberland and Westmorland, the Yoredale Series is best studied in Alston Moor, in Teesdale, and along the summit of the Pennine Escarpment; but for its fullest development we must look to the valleys and hills of Yorkshire, where it was originally described by Prof. Phillips, and where it sometimes attains a thickness of 1000 feet." Now this set of beds is bounded above by the Millstone-grit, and below by the Scar Limestone

[1] Read at the Bristol Meeting of the British Association, 1st September, 1875.

[2] Essay on the Geology of Cumberland and Westmorland, by H. A. Nicholson, D.Sc., F.G.S., etc., London and Manchester, 1868, p. 79.

Series, from which, however, it is separated by a sheet of basaltic trap well known in the North of England as the Great Whin Sill. It is to this lower limit that I wish to call particular attention.

Granting that no stratigraphical boundary could be more convenient than one marked by a non-intrusive, continuous, evenly-interbedded mass of trap, especially when we remember that, even in its typical localities, the Scar Limestone Series is (setting fossil evidence aside) only distinguished from the upper group by the thickness of its beds of limestone—granting this, it must yet be obvious that each one of these conditions is essential to the arrangement. If the basalt be shown to be intrusive, that is, injected among, and not merely over, hardened beds, if it be discontinuous in any portion of its course, if it shift its horizon to higher or lower portions of the Carboniferous mass, then this trap utterly fails as a natural divisional line.

Now in a paper read at the Bradford Meeting of the British Association in 1873[1] by my friend Mr. W. Topley, F.G.S., and myself, which has yet only been printed in abstract, we showed, I believe quite conclusively even to the late Prof. Phillips, who had formerly upheld the opposite view, that in its career across Northumberland to the North Sea the Great Whin Sill was distinctly and undoubtedly intrusive, that it was occasionally discontinuous, and that it was subject to changes of level so important as in some cases to carry it to a position *above* that very "Main" or "Great" Limestone which, as is stated in the quotation above, is one of the highest beds in the Yoredale Series. It is needless to repeat the detailed descriptions by which we established these facts, as the paper will probably before long be published in full; but if any scepticism remain on the subject, I would call attention to a section[2] which, in the words of one very competent to form an opinion, "satisfactorily clears up even to the most fastidious person the intrusive character of the rock."[3]

It is true that the Whin Sill in Durham and along the great Pennine Escarpment is wonderfully regular, and can, for those portions of its extent, be looked upon as, for all practical purposes, the equivalent of a truly interbedded or contemporaneous trap, although even there the signs of its intrusive nature were sufficient to convince so experienced an eye as that of the late Prof. Sedgwick. But surely the mere fact that north of Alston Moor its horizon cannot be depended on for any distance *along its outcrop*, is sufficient to throw the gravest doubt on the Basaltic sheet's continued geological horizon to the dip or eastern side. There is no reason to believe that an intrusive sheet of trap in which great and frequent shifts of level in one part of its area have been proved, would lie

[1] On the Whin Sill of Northumberland, by W. Topley, F.G.S., and G. A. Lebour, F.G.S. (Abstract in Report of the British Association for 1873, London, 1874, part 2, p. 92).

[2] On the 'Great' and 'Four-Fathom' Limestones and their associated beds in South Northumberland, by G. A. Lebour, F.G.S., etc., Trans. N. Engl. Inst. of Min. Eng., 1875, vol. xxiv. p. 140, and fig. i. pl. xxxiii.

[3] Mr. R. Howse, in discussion on above paper, *ibid.* p. 147.

persistently between the same beds in any other part of it, even if the examination of its outcrop in the latter region have revealed no change of horizon. Slight variations of level, however, seem to be admitted by some of the upholders of the interbedded character of the Whin Sill, even south of Northumberland.[1]

In arguing this point in conversation, I have sometimes been met with the objection that the Great Whin Sill was not really taken as the boundary between the Yoredale Series and the Scar Limestone Series, but that the bed of limestone lying upon it in the Alston District and along the Pennine Escarpment was taken as the bottom Yoredàle bed—this limestone being well known in the lead-mining districts as the "Tyne-bottom Limestone"—without reference to the trap, whose absence or presence had but an accidental connexion with the line of division. I believe that this ingenious way of shuffling out of the difficulty is of quite recent invention—dating, in fact, from the time when the true nature of the Whin Sill was conclusively shown. That it is so will be made apparent by a glance at the most authoritative geological maps of England which have appeared of late years. In them the Yoredales and the Scar, or Carboniferous Limestone proper, divisions will be found very clearly defined by a continuous red divisional line of Basalt—the Great Whin Sill—without a hint of any other demarcation being sought.[2] Again, passages such as the following, which testify similarly to the general acceptance of the trap-sheet as a base-line, might be multiplied with ease, viz. "Yoredale Rocks.—In this series we include all the strata from the Fell-top Limestone inclusive to the Great Whin Sill."[3]

My position then, with regard to the Great Whin Sill, is this: that being undoubtedly intrusive and subject to change of level, it is totally unfit to serve as the boundary line between two great divisions of the Carboniferous rocks.

Setting aside the great trap-sheet therefore, and seeking for a less fickle base for the Yoredale rocks in the North, we have offered us merely a bed of Limestone—the Tyne-bottom Limestone of the Alston miners.

This "Tyne-bottom Limestone" is the tenth calcareous bed mentioned by Westgarth Forster (in descending order) in his section of the strata of the Alston Moor District. It has no lithological character to distinguish it from the other limestones, either higher in the Yoredales above it, or in the Scar Series below; its thickness (about 22 feet) is not constant, even over a limited district; its fossils are useless for purposes of identification. Indeed, no bed perhaps in the entire Carboniferous Limestone Series in the North of England is more difficult of identification—certainly none has had

[1] Nicholson, *op. jam. cit.*, p. 78.

[2] The geological map which accompanies the Coal Commission Report is an exception, although in that map the assumed doubtful line of boundary between Yoredale and Scar is more out than usual, owing, doubtless, to the general character of the map.

[3] A Synopsis of the Geology of Durham and Part of Northumberland, by Richard Howse and J. W. Kirkby, Newcastle-on-Tyne, 1863, p. 22.

so many other beds taken for it. The reason of this is simply that, with the rooted belief that the Great Whin Sill was a regularly interbedded trap-flow, whatever calcareous band chanced to be found next above it was instantly supposed to be the Tyne-bottom Limestone. This identification was sometimes right and sometimes wrong (more often the latter), and it necessarily led to great confusion respecting the horizons of the beds above.[1] In the faulted district which lies to the North of Alston it would be a difficult thing to trace with any certainty a line of boundary depending on an ill-characterized bed such as this; but in this case the difficulty becomes almost an impossibility if we bring the following considerations to bear upon the subject.

It is no part of the object of this paper to describe in detail the beds which form the so-called Yoredale Series in Northumberland; but it is necessary, for a proper understanding of my argument, that I should refer to a paper in which I have shown that the several beds of limestone which make up the calcareous element of the series in the Alston District increase in number in its northern extension, that not only limestones of average thickness, but also grits, shales, and coals appear, and sometimes disappear, as intercalated beds of greater or less continuity.[2]

The Yoredales, which in the Alston District are about 500 feet thick, in about twenty miles of northerly trend increase to some 2000 feet, only a few of the more marked beds being traceable throughout. Among these the Tyne-bottom Limestone has no place. No one but a Wernerian miner, relying on the golden rule of thumb, could at the end of the twenty miles point out with any degree of certainty the bed which is indeed the "Tyne-bottom." It may be there, or it may have thinned out, as many others have been proved to do. At any rate, here is no fit base for a great stratigraphical division. In the Pennine Escarpment, however unphilosophical and unnatural the line might be shown to be, it is a convenient one. Here in mid-Northumberland it has not even that recommendation. No doubt a nearly correct approximate horizon could easily be found marking the level of the Tyne-bottom bed. But what would such an approximate line divide?

Above it, from 1000 to 2000 feet of grits, shales and limestones, and thin coals; below it, a much greater mass of grits, shales, limestones, and thin coals, similar in every respect to the series above. Similar lithologically, similar in the individual thicknesses of its beds (for the thick limestones of the Scar Series have disappeared by this time), and similar in fossils. Of what use can such a division be?

Nearly all the organisms which it was supposed characterized the Yoredales in Northumberland have now been found in the lower

[1] The Scar beds are not supposed to be worth much for lead-mining purposes, and are therefore, with a few striking exceptions, seldom worked into.

[2] On the "Little Limestone" and its Accompanying Coal in South Northumberland, by G. A. Lebour, Trans. N. Engl. Inst. Min. Eng. 1875, vol. xxiv. p. 1, *et seq.*

beds of the Carboniferous Series,[1] and the massive calcareous formation which sufficiently distinguishes the Scar Series to the south has given place in the west of this county to a mere extension below of the Yoredale Series above. In a sense it would be correct to say that in Northumberland the Yoredale Series is the only part of the Carboniferous Series below the Millstone-grit present, with the exception of the Calciferous Sandstone, or Tuedian, group.

But only in a very limited sense would this be true. When Prof. de Koninck, in receiving the Wollaston Gold Medal of the Geological Society in February last, took occasion to state, or rather to imply perhaps, that the faunas of the Carboniferous Limestone Series of the North of England and of Scotland were identical with that of the Calcaire de Visé (the uppermost of his three Belgian divisions),[2] he no doubt said so in this limited sense. Palæontologically there is no break in the northernmost part of England between the Scar and the Yoredale Series, but this only means that the circumstances of life and of deposition were in this region free from the changes which in the south determined those groupings of Carboniferous organisms which mark off into clear stages the Carboniferous Limestone as a whole. These northern beds are not the Yoredales alone, increased to an enormous thickness. They are the Yoredales *plus* the Scar Limestone, rendered indistinguishable by the geographical features of their time. They as truly represent the Tournai and the Dinant as they do the Visé division, although they may be homotaxeous with the last alone. The life conditions of Visé lasted in Northumberland from the close of the Calciferous or Tuedian age to the time of the Millstone-grit, or possibly to the beginning of the Coal-measure Period. Thus it is that in that part of England the Yoredales, the Scar Series, etc., are mere names without significance.

"In fact," as Prof. Ramsay has so well said, "viewed as a whole, the Carboniferous Series consists only of one great formation, possessing different lithological characters in different areas, these having been ruled by circumstances dependent on whether the strata were formed in deep, clear, open seas, or near land, or actually, as in the case of the vegetable matter that forms the coals, on the land itself."[3]

Since then no Yoredales proper and no Scar Limestones proper can be shown to exist, as such, in the great Carboniferous Limestone Series of Northumberland, and since no comprehensive name has been given to the blending of these two divisions which forms the link between the Yorkshire and the Scottish types of the series, and which is developed to its fullest extent in Northumberland, some special name denoting this series must sooner or later be coined. May I venture to suggest "Bernician Series" as a suitable term

[1] Up to the present time, the well-marked foraninifer *Saccammina Carteri*, Brady, is apparently limited to a bed in the Upper or Yoredale part of the series, viz. the Four-fathom Limestone.

[2] Abstract of Proc. of the Geol. Soc. of London, No. 296, p. 2.

[3] Physical Geology and Geography of Great Britain, by A. C. Ramsay, LL.D., F.R.S., 2nd edition, 1872, p. 76.

for these—the beds which in Northumberland lie between the Tuedian (or better *Valentian*, Geikie, MS.) Rocks and the Millstone-grit? The term explains itself, and gives no handle to theoretical misapplication.

IV.—Notes on West Indian Fossils.

By W. M. Gabb,
Of the Academy of Natural Sciences, Philadelphia, U.S.A.

On my return to civilization, after an absence of nearly three years, I observe in the Geological Magazine for 1874, New Series, Decade II. Vol. I., pp. 404 and 433, a paper by Mr. R. J. L. Guppy, of Trinidad, describing new species of fossils from the West Indian Tertiaries, to which is appended a list of the fossils known to him up to that date. Unfortunately Mr. Guppy has overlooked my Memoir on the Geology of Santo Domingo, published in the Transactions of the American Philosophical Society more than a year before the date of his paper. In that paper I nearly doubled the list of known fossils in the West Indian Miocene, basing my determinations on a collection of unprecedented magnitude, made during the prosecution of the Geological Survey of the Dominican Republic. Although ignorant of the existence of this paper, Mr. Guppy has been fortunate in not redescribing any of the species contained in it, so far as I can make out, save with the following exceptions:

Phos erectus, Guppy, Geol. Mag. Pl. XVI. Fig. 1, is the species described by me under the name of *P. Guppyi*, in recognition of that gentleman's extensive labours in the region.

I had previously pointed out that the shell described by Sowerby as *Conus solidus*, and re-named by Mr. Guppy as *C. recognitus*, is identical with Reeve's *pyriformis*.

Turritella planigyrata, G., is common in Santo Domingo, and Mr. Guppy's description must be amplified so as to cover individuals quite heavily, but always evenly ribbed.

I cannot indorse the suggestion of a new generic name for *Gouldia*, even granting the pre-occupation of the old name among birds. Numerous precedents exist for retaining the old, well-known name; and a following out of the same idea would create much more confusion in nomenclature than it would obviate.

I append a list of the fossil corals belonging to the Geological Survey Collection, and recently determined by Count Pourtales.

List of Fossil Corals collected by W. M. Gabb, Esq., in Santo Domingo.

By L. F. Pourtales.

The following list comprises all the fossil corals collected by Mr. Gabb in Santo Domingo. The greater number are stated to be from the Miocene, a few from the Post-Pliocene, and fewer yet from the Cretaceous. The latter are very much altered by fossilization, while among the former, many are in an excellent state of preservation.

The determination is of course based on the valuable papers on West Indian fossil corals, published by Prof. P. M. Duncan, F.R.S., in the Quarterly Journal of the Geological Society. A few forms appear to be new, but are not described as new species, partly because the specimens are imperfect, and partly because the living species, with which they could be compared or identified, are still in great confusion, as, for instance, in *Dichocœnia*, a genus in which the species appear to have been needlessly multiplied. Since the publication of Prof. Duncan's paper two genera, supposed extinct, have been found to be still living in deep water in the West Indies. They are *Trochocyathus* and *Antillia*. Deep sea-dredging will probably reveal still more.

CRETACEOUS.

Phyllocœnia ?	*Flabellum* ?

MIOCENE.

Placocyathus Barretti, Dunc.	*Antillia bilobata*, Dunc.
P. costatus, Dunc.	*Astrocœnia decaphylla*, E. & H.
Platytrochus, or *Smilotrochus*, sp.	*Meandrina labyrinthiformis*, Oken.
Astrohelia vasconiensis, E. & H.	*M.* sp.
Madrasis decastis, Verrill.	*Diploria cerebriformis*, E. & H.
Stylophora affinis, Dunc.	*Maricina areolata*, Ehrbg.
Asterosmilia exarata, Dunc.	*Orbicella cavernosa*, Dana.
A. anomala, Dunc.	*O. endothecata*, Dunc. sp.
A. coronata, Dunc.	*Cyphastræa*, sp.
Trochosmilia multisinuosa, E. & H.	*Plesiastræa ramea*, Dunc.
Dichocœnia Stokesi ? E. & H.	*Siderastræa galaxea*, E. & H.
D. tuberosa, Dunc.	*S. siderea*, Blainv.
Tekiophyllia grandis, Dunc.	*Agaricia agaricites*, Lmk.
T. sp.	*Porites furcata*, Lmk.
Euphyllia, sp.	*Pocillopora crassoramosa*, Dunc.

POST-PLIOCENE.

Dichocœnia, sp.	*Colpophyllia gyrosa*, E. & H.
Stephanocœnia interrupta, E. & H.	*Orbicella cavernosa*, Dana.
Eusmillia fastigiata, E. & H.	*O. endothecata*, Dunc. sp.
Meandrina strigosa, Dunc.	*Plesiastræa ramea*, Dunc.
Manicina areolata, Ehrbg.	*Porites astræoides*, Lmk.

V.—NOTES ON DIAMONDS FROM THE CAPE OF GOOD HOPE.[1]

By Professor TENNANT, F.G.S.

THE first South African diamond was found in March, 1867, and on examining its physical characters, it was pronounced by Dr. Atherstone to be genuine. When this stone was received in London, it created considerable interest, and also some degree of suspicion, some persons having asserted that it was brought forward for mercenary purposes; letters even appeared in the public papers implying that it was impossible it could have been found near Hope Town. As Dr. W. G. Atherstone, F.G.S., of Graham's Town (who in March, 1867, examined and pronounced the stone to be a diamond), is now in Bristol, I beg to offer a few general remarks on the Cape diamonds, and also to express in public my thanks to him.

The late Mr. Mawe, who wrote on diamonds, and described their mode of occurrence in his Travels in Brazil (London, 1812), often expressed to me his opinion of the probability of their existence in

[1] Read before the Geological Section of the British Association at Bristol, September 1st, 1875.

South Africa, and said that if people only knew them in the natural state he felt confident they would be found.[1] He died in 1829, and I took every opportunity to make the subject known by means of short papers, accompanied by figures showing the ordinary crystalline form of the diamond.

The number and quality of diamonds from the Cape are equal to those from the Brazils, which have chiefly supplied Europe during the last eighty years.

About ten per cent. of the Cape diamonds may be classified as of the first quality, fifteen per cent. of the second, twenty per cent. of the third; the remainder, under the name of *bort*, are employed for cutting diamonds, and for the various economic purposes to which this valuable substance is applied by the glazier, the engineer for drilling rocks, the lapidary, and others. Many diamonds contain specs and cavities; these are placed in the hands of skilled workmen who are acquainted with the cleavage, and by careful manipulation they are frequently able to remove these blemishes, and so to obtain portions of the gems of the first quality for making small "brilliants," "roses," and "tables."

The cutting and polishing of diamonds was carried on in London with great success 200 years ago; subsequently it was carried on chiefly in Holland; but several attempts have been made to re-establish the trade in this country.

In 1874 the Turners' Company offered prizes, in the form of medals and the freedom of the City of London, for the best specimens of diamond-cutting. The Baroness Burdett-Coutts has supplemented this by the addition of money prizes, and has offered to contribute the further sum of £50 for prizes in the year 1876.

It is estimated that the value of the diamonds found at the Cape from March, 1867, to the present time, exceeds twelve millions of pounds sterling.

I am enabled to exhibit not only a large collection of these diamonds, but also samples of the natural materials found associated with them.[2] In November, 1873, one of my former students brought me the specimen from South Africa represented in Fig. 1, which in its original state weighed 112 carats; it has since been cut by a London firm of diamond-cutters into the beautiful brilliant represented by Figs 2, 3, and 4, weighing 66 carats. The stone has a delicate yellow tinge, and exceeds *in size and brilliancy any diamond in the British Crown.*

It may be remarked, with regard to this class of gem-cutting, that 200 years since the English diamond-cutters were the most celebrated in the world. The diamond-cutting trade is now coming back to England, and the stone figured above affords a fair sample of what excellent work can now be done here. I may mention that the stone in its present form is worth £10,000,

[1] Prof. Tennant explained that the diamond in its natural state bore considerable resemblance to a piece of gum.

[2] Prof. Tennant exhibited a South African diamond in the matrix (consisting chiefly of broken fragments of chloritic and clay-slates), likewise some interesting photographs of the Diamond-workings in South Africa.

whilst the value of the models of it, which have been cut by the best lapidaries, is a mere trifle, that in glass costing but 10*s*., and that in crystal but £2. The rule given by Jeffries and the best authorities upon diamonds for ascertaining the value of cut diamonds, is to multiply the square of the weight in carats by eight, and call it pounds, so that this diamond would, according to this computation, be worth 66 × 66 × 8 = £34,848.

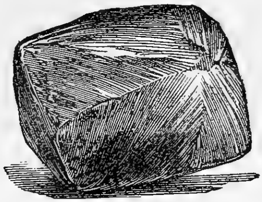


Fig. 1.

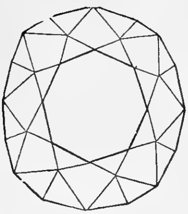


Fig. 2, Front View.

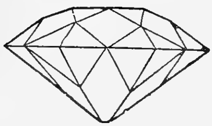


Fig. 3, Side View.

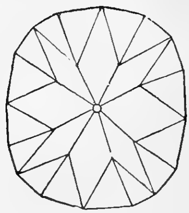


Fig. 4, Back View.

Fig. 1.—Natural Crystal of a Diamond recently found in South Africa.

Figs. 2–4.—Three views of the same stone after having been cut as a brilliant by a London diamond-cutter.

VI.—Nomenclature of the Drift.

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

In the short notice on the Drift (Geol. Mag. July, 1875, p. 328) I did not mean specially to condemn Mr. Birds; the paper being intended as a general protest against the loose nomenclature used by former writers and adopted by those of the present day.

As to the Irish gravels, they have never been systematically examined or classed. We have different gravels—1st, under the 25-feet contour-line; 2nd, under the 110-feet contour-line; and 3rd, under the 350-feet contour-line—all more or less containing marine shells. Although these gravels are of distinct ages, yet the fossils collected from them have been lumped together. Then older than the Esker gravels (under the 350-feet contour-line), there are gravels at about the following respective heights—550 feet, 750 feet, and 1200 feet, some of which contain fossils, and although these gravels must be much older than the three groups first named, yet their fossils have been all classed together. I remember hearing my brother, the late Dr. Kinahan, remark that the group of fossils from the gravels at Bohernabreena (about 200 feet) were distinct from the group found in the gravels at Howth and the coast to the northward (under 100 feet). In no place in Ireland have I seen gravels belonging to the first three groups (the third being the so-called "middle gravels") under normal glacial drift, although I have found gravels belonging to all the others so situated.

In Ireland the resurrectionists have employed very loose evidence to reinstate their "middle gravel," and from what I have seen in some places in England, very similar evidence has been used there also. After the ice and waters of the different seas disappeared from the face of the country, the latter must have been more or less destitute of a protecting envelope of vegetation; therefore meteoric abrasion had a maximum denuding power, that formed extensive sheets of a re-arranged drift. These accumulations in low places were thick, but gradually thinned as they ascended heights. This process may be seen going on at the present day in the neighbourhood of Swansea, where the sulphurous fumes from the furnaces have destroyed vegetation, while Agassiz mentions the formation of a similar drift in Brazil. This re-arranged drift in places in Ireland has been made to do duty as "Upper Boulder-clay," and I was shown a similar drift in Lancashire as "Upper Boulder-clay." I am very much afraid that the statement made by the President of Section C. at the late Meeting of the British Association in Bristol is too true; and that there is no one living capable of writing about the Glacial Period, as our knowledge of it and what probably took place during it is very crude. In the County Dublin there are low and high level gravels and drifts containing marine shells; and the various writers on the subject, myself among the number, have put forward more or less vague speculations and theories to account for the difference in their levels; while none of us ever thought of collecting the fossils from the different zones, and seeing if they formed similar groups. If the latter was done, I would not be surprised to hear, the groups had more or less different characters, showing the gravels to be of different ages.

VII.—A Chapter in the History of Meteorites.

By Walter Flight, D.Sc., F.G.S.,
Of the Department of Mineralogy, British Museum.

(*Continued from page* 504.)

Found 1861.—Breitenbach, Bohemia.[1]

This remarkable siderolite was found in Bohemia, at a spot not very far distant from the Saxon frontier or indeed from Rittersgrün, in Saxony, where a mass closely resembling it was almost contemporaneously found. So far back as 1751 at Steinbach, a village about midway between Breitenbach and Rittersgrün, a meteorite in all respects similar was discovered; the three masses are so similar to one another and so dissimilar to any others preserved in collections that there can be little doubt that they belong to the same fall. In 1825 Stromeyer examined a siderolite in which he found 61·8 per cent. of silica; this also appears to have been a member of this

[1] N. Story-Maskelyne. *Proc. Royal Soc.* 1869, xix. 266.—V. von Lang. *Sitzber. Ak. Wiss. Wien*, 1869, lix. 848. *Pogg. Ann.* cxxxix. 315.—N. Story-Maskelyne. *Phil. Trans.* 1871, clxi. 359.—G. vom Rath. *Zeit. Deut. Geol. Gesell. Berlin*, 1873, xxv. 106. *Pogg. Ann.* Erganz.-Bd. vi. 337. *Jahrb. Mineralogie*, 1874, i. 79.

shower of meteorites, believed by Breithaupt to have been the "Eisenregen" which occurred at Whitsuntide, 1164, in Saxony, when a mass of iron fell near the town of Meissen.

A polished surface of either of these masses exhibits irregularly formed patches of nickel-iron, the interspaces being partly filled with small patches of iron sulphide, the greater portion of the surface being occupied by a greenish and greyish-brown crystalline magma. After the removal of the two first-mentioned ingredients with mercury chloride, the magma is found to consist of (1) highly crystalline, bright green or greenish-yellow grains; (2) rusty-brown, sometimes nearly black, sometimes also nearly colourless grains of a mineral presenting crystalline features, but on which definite planes are rare; and (3) crystalline grains of chromite.

The first of these ingredients is bronzite, the crystallographic characters of which are described in the paper of von Lang, who gives the results of measurements made on nine crystals; these results are mineralogically important as affording for the first time complete data for the crystallography of a rhombic mineral having the formula of enstatite. The elements of the crystal are:

$$a : b : c = 0{\cdot}87568 : 0{\cdot}84960 : 1$$

which give the following among the important angles by calculation:

$$110,010 = 44^\circ\ 8'$$
$$101,100 = 41^\circ\ 11'$$
$$011,010 = 40^\circ\ 16'$$

Von Lang observed the following faces:

100, 010, 001, 011, 054, 302, 101, 102, 103, 104, 410, 520, 210, 530, 110, 120, 250, 130, 111, 121, 112, 122, 212, 133, 232, 124, 144, 324, 344, 524.[1]

The most important zonal relations of these faces are shown in the spherical projection appended to his paper.

The hardness of this mineral is 6 and the specific gravity 3·238, a number differing but slightly from those determined by Stromeyer and estimated by Rumler in the case of the silicates of the Steinbach siderolite. The composition of the bronzite, as determined by analyses made by the new method of distillation already alluded to (page 408) and by fusion with alkaline carbonates, was found to be:

	I.	II.	*Mean.*	*Oxygen.*
Silicic acid	56·101	56·002	56·051	29·89
Magnesia...	30·215	31·479	30·847	12·34
Iron protoxide...	13·583	13·295	13·439	2·97
	99·899	100·776	100·337	

These numbers correspond very closely with the formula $(Mg_{\frac{4}{5}}\ Fe_{\frac{1}{5}})SiO_3$. This bronzite, which occurs in association with nickel-iron, contains only half the amount of iron met with in the bronzite of the Manegaum meteorite (page 403), which stone contains next to no nickel-iron. Rammelsberg[2] has recently pointed out the fact

[1] About the time that von Lang published these results vom Rath measured some crystals of terrestrial bronzite, found in a sanidine bomb from the Laachersee, and arrived at results which accord very exactly with those of von Lang. (*Pogg. Ann.*, cxxxviii. 529.)

[2] C. Rammelsberg. *Pogg. Ann.*, cxl. 311. Rammelsberg draws attention to the remarkable accordance between the angles of bronzite and olivine, which would explain the fact of G. Rose having regarded the silicate in the siderolites of Rittersgrün and Steinbach as olivine. (See note to page 313.)

that in Stromeyer's paper, already alluded to, the specific gravity of the silicate is given = 3·27; and he shows that, although the mineral analysed by Stromeyer contained undecomposed silicate, or more probably asmanite, the ratio of Fe to Mg is the same as in the above analyses.

By treating with hydrochloric acid the dark-coloured grains constituting the second ingredient of the meteorite and forming about one-third of the mass of the mixed silicates the iron staining them is removed, and they are left in a state of colourless purity. This mineral, to which Maskelyne has given the name asmanite,[1] is silicic acid, possessing the specific gravity of quartz after fusion, and crystallising in forms belonging to the orthorhombic system. The grains of asmanite are very minute and much rounded, and, although entirely crystalline, they very rarely present faces offering any chance for a result with the goniometer; from several thousand little grains comprised in some two grammes of material Maskelyne obtained a very few crystals with sufficiently distinct crystallographic features to be available for measurement. He found the parametral ratios of asmanite to be:

$$a : b : c = 1·7437 : 1 : 3·3120$$

The angles, as calculated from these data and as found on seven different crystals, are as follow:

		A.	B.	C.	D.	E.	F.	G.
100,403 =	21° 33′	...	...	21° 31′				
101 =	27 46	27° 40′	27° 48′	27 46	27° 49′	27° 25′	27° 55′	27° 44′
102 =	46 29	46 18	...	46 31	...	46 2		
103 =	57 40	...	...	57 34	...	...	57 25	57 35
001 =	90 0	90 0	...	90 0				
001,$\bar{1}$03 =	32 20	32 22	...	32 19				
$\bar{2}$03 =	51 42	51 32						
$\bar{1}$02 =	43 31	43 34						
$\bar{1}$01 =	62 14	62 17	...	62 14				
100,010 =	90 0							
110 =	60 10	...	60 13	60 10	...	...	60 10	
$\bar{1}$10 =	119 50							
110,1$\bar{1}$0 =	120 20	...	120 23	...	...	...	120 10	
001,011 =	73 12							
010 =	90 0	...	...	90 0				
101,110 =	63 53	...	...	63 54				
$\bar{1}$10 =	116 7	...	...	116 7				
001,116 =	32 28	...	...	32 56				
112 =	62 21	...	...	62 21				
223 =	68 33	...	...	68 36				
110 =	90 0	...	...	90 0				
548,001 =	63 52	...	...	64 0				
100 =	58 28	...	...	58 30				
101 =	52 18	...	...	51 48				

The cleavage-plane 001 has a vitreous lustre, that on the planes of the forms 100 and 101, as also of the rounded surface in the zone with them, is usually resinous, recalling the lustre of opal. The

[1] Ásman is the Sanscrit term, corresponding to the Greek ἄκμων, for the thunderbolt of Indra.

faces of the octaid forms are almost invariably rounded. The optical characters confirm the measurements in showing asmanite to be rhombic, the optic axes being very distinct and widely separated; their apparent angle, as measured in air, is 107° to 107° 30′.

The hardness of this mineral is 5·5, and the specific gravity 2·245; according to vom Rath 2·247. Of the following analyses, I. and II. are the original analyses given in Maskelyne's paper, III. are the results of a recent analytical examination by vom Rath:

	I.	II.	III.
Silicic acid	97·430	[99·210]	96·3
Iron oxide	1·124	0·790 (Iron oxide, Lime, Magnesia together)	1.6
Lime	0·578		trace
Magnesia	1·509		1·1
	100·641	100·000	99·00

It is not a little curious to find that in his Catalogue of the Vienna Collection Partsch[1] describes a specimen of the Steinbach meteorite as "native iron, jagged and hackly, *with quartz in grains*, and a yellow fluorspar." The detection by G. Rose of quartz in the oxidised crust of the Toluca iron is the only earlier instance recorded of the occurrence of free silica in a meteorite. The solvent action of an aqueous solution of sodium carbonate on asmanite and quartz in powder appears to be uniform.

As regards the relation in which the three forms of crystallised silicic acid stand to each other in respect to the mode of their formation, vom Rath remarks that while crystals of quartz have in most cases unquestionably separated from aqueous solution, and tridymite, as a characteristic mineral of the druses of volcanic rocks, appears to require the co-operation of vapour for its formation, we have probably in asmanite silicic acid crystallised from a molten mass which has become solid. Crystallised silica has not yet been produced by fusion; when it is, it will probably have the characters of asmanite.

The nickel-iron of this siderolite exhibits figures when etched, and consists of:

	I.	II.	*Mean.*	*Equivalent Ratios.*
Iron...	89·975	90·878	90·426	3·229
Nickel	9·642	8·927	9·284	0·314
Cobalt	0·383	0·195	0·290	0·010
Copper	trace	trace		
	100·000	100·000	100·000	

The above ratios differ but slightly from Fe : (Ni, Co) = 10 : 1. Rube's examination of the Rittersgrün iron yielded very similar per-centage numbers. The chromite of this siderolite gives angles corresponding to a regular octahedron.

[1] P. Partsch. Die Meteoriten im k. k. Hof-Mineralien-Kabinette zu Wien. 1843. Page 95.

Found 1861.—Cranbourne, near Melbourne, Australia. [Lat. 38° 11′ S.; Long. 145° 20′ E.][1]

This enormous block of meteoric iron, which is a familiar object to those frequenting the British Museum, is, with the exception of the recently found Ovifak irons, preserved at Stockholm and Copenhagen, the largest meteorite contained in any collection. The minerals composing it have for some time past formed the subject of an investigation, and the results which I have obtained will shortly be published. It will suffice here to state that the Australian, like the Greenland irons, oxidises on exposure to moist air and scales off. These masses differ in that the Ovifak iron yields a rusty-brown coarse powder, apparently without structure; in the débris of the Australian iron, on the other hand, distinct crystals of nickel-iron are to be met with. Though partially converted into oxide and readily broken when handled, they attain after treatment with an excess of hydrogen at a red heat their pristine stability. A number of crystals, apparently tetrahedra, of nickel-iron, large and very perfect, as well as plates of what may possibly be beam-iron and which lie, though not immediately, upon them, were reduced by this method: I had the honour of showing a small suite of them at the Soirée of the Royal Society on the 26th May last. Between these two forms lie excessively thin plates of an alloy of iron, much richer in nickel, and to the diminished action of an etching fluid on this more stable alloy I ascribe the development of such thin lines as are seen in the section of the Toluca iron (see Plate IX. p. 311). The descriptions and analyses of these and other minerals will appear in the memoir which I have in preparation. I have now to refer the reader to von Haidinger's early notices[2] of the discovery of this block, based for the most part on a report supplied by Neumayer, at that time Director of the Flagstaff Observatory at Melbourne. Two masses of meteoric iron were discovered, and near the larger meteorite Neumayer found a brown ochrey mineral which he regarded as a portion of its oxidised crust. It had but feeble action on the magnet and did not fuse before the blowpipe, but turned black and became magnetic. The hardness is rather less than that of felspar, and the specific gravity = 3·744; the composition, according to a recently published analysis by Haushofer, is:

Insoluble silicate	4·1
Silicic acid	2·3
Alumina	1·5
Iron oxide	71·1
Nickel oxide	3·1
Lime	1·8
Phosphoric acid	1·4
Water	13·7
	99·0

[1] K. Haushofer. *Jour. Prakt. Chem.*, 1869, cvii. 330.—M. Berthelot. *Ann. chim. et phys.* 1873, xxx. 419.

[2] W. von Haidinger. *Sitzber. Ak. Wiss. Wien*, 1861, xliii. 583; xliv. 378 and 465; and 1862, xlv. 63.

The author suggests that more or less rounded masses of nickeliferous göthite or limonite having a similar origin may probably be met with in the older sedimentary rocks.

In continuation of his valuable researches on the native and artificial varieties of carbon,[1] Berthelot examined a specimen of the graphite-like carbon, which I found among the fragments of metal detached from this iron. His object was to ascertain which variety of carbon it resembled, whether it should be classed with the graphite of pig-iron, native plumbago, the amorphous carbon obtained by treating carbides of iron or manganese with acid, the so-called artificial graphite of the gas-retorts which he had previously shown to be no true graphite, anthracite, or, lastly, the carbonaceous substance found in the remarkable meteorite which fell at Orgueil (1864, May 14th).[2]

The carbon of the Cranbourne meteorite was warmed with nitric acid to remove the iron sulphide, and then digested with fuming nitric acid and chlorate of potash. After two treatments with these powerful oxidising agents, Berthelot obtained a greenish graphitic oxide, identical in every respect with the oxide obtained from the graphite of cast iron, and differing as entirely from the oxidised product which plumbago yields under like conditions. As this meteoric carbon resembles in all respects the variety of this element which has been dissolved in molten iron and separated from the solidified mass after very rapid cooling, Berthelot suggests that its formation and association with the meteoric form of iron sulphide[3] may be ascribed to the action of sulphide of carbon on incandescent iron, since the carbon of the last-mentioned sulphide by decomposition is also liberated in the graphitic form. The carbon of this meteoric iron owes its present form to exposure to a very high temperature; it cannot have been produced by the action of iron on carbonic oxide or from carbon once combined with the metal and liberated at ordinary temperatures by the solution of the iron in some reagent; and is still further removed from the other variety of meteoric carbon occurring in the stone of Orgueil. The carbon of the Ovifak iron (see page 120) has likewise been examined by Berthelot. He finds it to differ so completely in its behaviour with oxidising reagents from the carbon of the Australian iron that he does not hesitate to pronounce the conditions under which these two forms of the element were produced to have been essentially distinct.

[1] M. Berthelot. *Ann. de Chim. et de Physique*, xix. 405.

[2] Wöhler and Cloez have found that certain of the carbonaceous meteorites contain compounds of carbon, hydrogen, and oxygen, resembling the last residues of organic substances of terrestrial origin. By applying his method of hydrogenation to the carbonaceous matter of the Orgueil meteorite, he succeeded in forming a notable quantity of a hydrocarbon of the series (C_{2n} H_{2n+2}) comparable with the oils of petroleum. This new analogy between the carbonaceous matter of meteorites and substances of organic origin occurring in the crust of our planet is of great interest. (*Compt. rend.*, lxvii. 849.)

[3] Troilite in large nodules is abundantly present in this meteoric iron.

Fell 1862.—Victoria West, Cape Colony, S. Africa.[1]

This mass is of interest as belonging to the very small class of meteoric irons the fall of which was witnessed. It is stated to be shaped like a pear, the one end being smooth and rounded, the other and smaller end being jagged in a manner which indicates the probability of its having been detached from a larger meteorite.

In 1870 the mass, which weighed $6\frac{1}{2}$ lbs., was sawn in two by order of the authorities of the South African Museum at Cape Town, and the one half further divided for distribution.

Tschermak has already shown that the meteorites of Ilimaë (see page 77) and Jewell Hill (see pages 77 and 501) enclose lamellæ of troilite, which are situated parallel to the faces of the cube; he now finds this iron furnishes a third example of this structure. The section of the iron is not only traversed by fissures, which were evidently once filled with troilite and in many cases still enclose traces of that mineral, but perfect plates of the sulphide are likewise observed. As in the former instances, the troilite lamellæ lie parallel to the faces of the cube, and are enclosed in a shell of beam-iron (kamacite). The etched figures are very distinct, and nodules of granular troilite are also met with.

Dr. L. Smith also directs attention to these fissures, and finds the figures developed by etching to be of that class where the lines are delicate and straight, inclined at a considerable angle to each other, a form common in irons rich in schreibersite. The latter mineral is diffused through the iron in masses with straight boundaries, $\frac{5}{8}$ in. to $\frac{3}{4}$ in. long, and $\frac{1}{8}$ in. in breadth, also in much narrower and longer forms, as well as in others which are triangular and arrow-shaped.

In a drawing accompanying his paper we have an interesting illustration of the specimen which he examined. In the centre of the section a cavity is seen, $1\frac{1}{2}$ in. in the longest and 1 in. in the shortest diameter, the interior of which is also coated with a layer of schreibersite $\frac{1}{20}$th in. thick; the rest of this cavity is stated to be filled with pyrites. In his later paper, however, the nodule is said to consist of the monosulphide, troilite. In the absence of the knowledge of any test, whether with chemical reagents or with the magnet, having been applied, it appears not improbable that some of the elongated enclosed masses described above as schreibersite may be the lamellæ of sulphide which Tschermak observed.

The specific gravity of this iron is 7·692, and the composition:

Iron = 88·83; Nickel = 10·14; Cobalt = 0·53; Phosphorus = 0·28; Copper = trace. Total = 99·78.

Found 1862.—Howard Co., Indiana.[2]

This mass of meteoric iron, which weighs 4 kilog. and has an irregular elongated oval form, was found in a bed of stiff clay about two feet below the surface. It is one of the class of irons which is

[1] G. Tschermak. *Mineralogische Mittheilungen*, 1871, 109.—J. L. Smith. *Amer. Jour. Sc.*, 1873, v. 107, and 1874, vii. 394.—See also G. R. Gregory. Geol. Mag. 1868, v. 531.

[2] J. L. Smith. *Amer. Jour. Sc.*, 1874, vii. 391.

only slightly affected by atmospheric agency, freshly cut surfaces retaining their brightness perfectly. The specific gravity of the iron is 7·821 and the composition :

Iron = 87·02; Nickel = 12·29; Cobalt = 0·65; Phosphorus = 0·02; Copper = trace. Total = 99·98.

An etched surface does not give the slightest indication of Widmanstättian figures; their occurrence in short appears to be an exception rather than the rule in the case of irons containing more than 9 or 10 per cent. of iron (see page 80).

Dr. L. Smith, while seeking for a satisfactory explanation of the formation of these figures, expresses his belief that we shall not arrive at a satisfactory explanation until our knowledge of the effect of the presence of a minute quantity of foreign substances in iron is better understood. He alludes to the power iron, containing one per cent. or even a less amount of phosphorus, acquires of withstanding the action of acid, as evidenced in vessels used for parting gold and silver. During the crystallization of iron, as of other substances, "there is a tendency to eliminate foreign constituents to the exterior portion of the crystals": after a blast-furnace, for example, has been chilled and the metal has slowly passed from a plastic to a solid condition, the iron will be found in large crystals containing a very much smaller amount of carbon than is usually the case. If meteoric iron then be rapidly brought to the solid state, we can conceive of such a diffusion of the phosphorus as would give no marked indications in any part of the mass; by slow cooling, however, we might expect a more or less complete elimination of the phosphorus in certain parts representing the spaces between the crystals of the mass. "The portions of the iron forming the limits of the crystals become more richly charged with phosphorus," the homogeneous character of the "iron" is destroyed, and this would render its different parts variously susceptible to the action of an etching fluid.

The irons of Victoria West, South Africa (see above), and Tazewell Co., which enclose nodules of troilite and schreibersite, contain, the former only a trace of sulphur and 0·28 per cent. of phosphorus, the latter 0·016 per cent. of phosphorus; and in the mass of the Arva iron, which is filled with layers of schreibersite, there remains only 0·019 per cent. of phosphorus. The geologist and mineralogist have noticed such a segregation in a vast number of instances.

1863, March 16th.—Pulsora, N.E. of Rutlam, Indore, in Central India.[1]

In his descriptive catalogue of the meteorites in the Vienna Collection, which is dated 1st October, 1872, Tschermak describes this stone as chondritic, and as consisting of olivine and bronzite with nickel-iron. It occupies a place between those marked *C w* (white rock without spherules) and *C g* (grey rock with light-coloured spherules). The letters *C i b*, affixed to it in the catalogue, denote that it has a brecciated structure like the meteorites of Dacca and St. Mesmin.

[1] G. Tschermak. *Mineralogische Mittheilungen*, 1872, 165.

[1863.]—South-Eastern Missouri.[1]

Shepard describes a small mass of meteoric iron originally weighing about 12 oz. which was found by Prof. Shumard in 1863 in the collection of the old Western Academy of Sciences of St. Louis; the only locality given on the label is "*S. E. Missouri.*" Shepard finds it to resemble most closely the irons of Arva and Cocke Co. The specific gravity is 7·015—7·112. The metal encloses so large a quantity of schreibersite that after prolonged treatment with acid that mineral projects in thick laminæ from the surface, as mica does from coarse-grained weathered granite. The intermediate areas are not traversed with the delicate lines of the same substance (?) as in the case of other irons. The meteorite has the following composition:

Iron = 92·096; Nickel = 2·604; Schreibersite = 5·000. Total = 99·700.

with traces of cobalt, chromium, phosphorus, magnesium, carbon and silicium.

Found 1864.—Wairarapa Valley, Province of Wellington, New Zealand.

I have to thank Dr. Hector, F.R.S., Director of the Geological Survey of New Zealand, for a short account of the only meteorite which has yet been found in that colony, and which is preserved in the Colonial Museum at Wellington. It is in the form of an irregular six-sided pyramid, 7 inches high and 6 inches across the base; the edges are rounded, and the sides slightly convex and indented with shallow pits. The capacity of the stone is 49 cubic inches, the weight 480 oz., and the specific gravity 3·254; the hardness 5–6. It is strongly magnetic, but exhibits no decided polarity. The surface is of a light rusty brown colour, and is stained with exudations of iron chloride and sulphate. A freshly fractured surface is dark grey, mottled with bright metal-like particles of what may be iron monosulphide. By treatment with copper sulphate, the presence of iron in the form of metal was determined; with hydrochloric acid sulphuretted hydrogen was evolved, sulphur set free, and a large quantity of gelatinous silicic acid separated. The insoluble portion consisting of silica and insoluble silicates constituted 56·0 per cent. of the stone. In the soluble portion the predominating ingredients were iron, amounting to 24·01 per cent. and magnesia along with nickel, manganese and soda; alumina and chromium are not present. These reactions so far indicate in the New Zealand meteorite the presence of olivine and an insoluble silicate, in addition to nickel-iron and what may be troilite or magnetic pyrites. A short notice of this stone is to be found in the Appendix A to the Jurors' Report of the New Zealand Exhibition of 1865, p. 410. Von Haidinger alludes to the circumstances attending the fall of a meteorite of this date (*Sitzber. Ak. Wiss. Wien,* lii. 151).

[1] C. U. Shepard. *Amer. Jour. Sc.*, 1869, xlvii. 233. In the catalogue of the Vienna Collection this iron bears the date 1864.

1865, May 23rd.—Gopalpur, Bagerhaut, Jessore, India.[1]

In his paper communicated to the Vienna Academy Tschermak gives the history of the fall of this stone,[2] from which it appears that its descent was unattended by the detonation which usually accompanies the descent of a meteorite. The stone, of which three views are given in Tschermak's paper, has a greyish brown colour; when laid on the largest flat surface it has approximately a trapezoidal boundary, the upper side being curved and exhibiting pits and striped markings. The front surface (*die Brustseite*) is covered with a thin feebly lustrous crust which is finely striped and channelled; thec hannels have a radiate arrangement and converge to a point near which is a small deep pit, while not far removed from it is another deeper-lying hollow; all the pit-like depressions are elongated, the extension being more marked the shallower they become and the further they lie from the point of radiation. It will be evident from this that during the transit of the meteorite through the atmosphere this point was in front. (See the Tucson iron, page 499.) The heat generated by the compression of the air melts the surface of the stone, and the attrition of particles of air with the more porous portion of the front surface forms the depressions radiating from the foremost point; the fused drops as fast as formed are driven off by the opposing air and give rise to the fine radiated texture of the crust. The hinder surface has very different characters: it consists of two almost flat faces meeting nearly at right angles and forming sharp edges with the front surface. Along this edge the very distinctive crust of the front surface slightly overlaps the hinder portion, terminating in a well-defined and sometimes fringed border. Here the crust is verrucose, most of the granules consisting of fused matter, many enclosing unaltered grains of the meteorite; few follow the radiated arrangement observed in the former case.

As regards the structure of the stone of Gopalpur it closely resembles, in the diminutive size of its chondra, the meteorites of Pegu and Utrecht. They are of three kinds: 1). The most striking have a brownish-grey hue and fibrous fracture, their optical principal sections being parallel and perpendicular to the direction of the fibres; these appear to be bronzite; 2). The next have a radiate structure, and are built up of larger bar-like transparent crystals, which in one spherule were observed to radiate from two centres; these are not improbably a felspar; and 3). The last kind of chondra consist of a granular fissured mineral which appears to be olivine.

The spherules have the same composition as their matrix, bronzite, olivine, nickel-iron and magnetic pyrites forming the predominating constituents in each case. While the chondra, met with in terrestrial rocks, in perlite, obsidian, pitchstone, in many diorites, are radiate-fibrous, those occurring in meteorites are but rarely so, and in these cases the arrangement of the fibres within the spherule is excentric. Moreover, while the meteoric chondra, as already stated, consist of

[1] G. Tschermak. *Sitzber. Akad. Wiss. Wien*, 1872, lxv. 135. *Mineralogische Mittheilungen*, 1872, 95.—A. Exner. *Mineralogische Mittheilungen*, 1872, 41.

[2] *Proc. Asiat. Soc. Bengal*, 1865, 94.

the same ingredients as the matrix, and often differ from it only in being more coarsely granular, the chondra of terrestrial rocks are shown by the microscope to be differently constituted from the matrix. Tschermak is of opinion that in the case of the meteorites solid masses have been reduced to powder by mutual attrition, the tougher particles withstanding the action becoming rounded, and that dust and spherules have undergone subsequent segregation.

The stone of Gopalpur consists, according to Exner's analysis, of:

Nickel-iron	20·35
Magnetic pyrites	4·44
Olivine	28 86
Bronzite	35·60
Felspar	10·75
Chromite	trace
	100·00

The nickel-iron has the following composition:

Iron = 90·37; Nickel = 9·11; Cobalt = 0·52. Total 100·00.

and the portions separated by acid:

	SiO_2	Al_2O_3	FeO	MnO	CaO	MgO	K_2O	Na_2O	
A. *Soluble*......	38·31	0·54	25·72	—	0·72	34·71	—	—	= 100·00
B. *Insoluble*...	57·95	5·19	10·03	0·57	3·04	21·42	9·45	1·35	= 100·00

This, it will be seen, is one of the few meteorites containing a variety of felspar, which in this instance amounts to more than 10 per cent. Tschermak was unable to determine by an examination of microscopic sections whether it was oligoclase.

1865, August 25th.—Sherghotty, near Gya, Berar, India.[1]

According to Lumpe's analysis, given below, this meteorite consists almost exclusively of silicates, only a trace of metallic iron and a very small amount of sulphur having been met with. It contains:

Silicic acid	50·21
Alumina	5·90
Iron protoxide	21·85
Magnesia	10·00
Lime	10·41
Soda	1·28
Potash	0·57
	100·22

These results show that the Sherghotty stone belongs to the class including the meteorites of Stannern, Juvinas, and Jonzac. The stone examined by Crook in Wöhler's laboratory contained more than nine per cent. of nickel-iron and very little lime, from which it is apparent that what Crook held to be the meteorite of Sherghotty is a specimen of another fall.

[1] E. Lumpe. *Mineralogische Mittheilungen*, 1871, 55.—G. Tschermak, *Mineralogische Mittheilungen*, 1871, 56; and 1872, 87; *Sitzber. Ak. Wiss. Wien*, 1872, lxv. 122; *Jahrbuch für Mineralogie*, 1872, 733.—See also F. Crook. On the Chemical Constitution of the Ensisheim, Mauerkirchen, Sherghotty, and Muddoor Stones. Inaug.-Dissert.) 1868. Gottingen: E. A. Huth.

More recently this meteorite has been submitted to a very complete investigation by Tschermak. He finds a fractured surface to be distinctly granular; the grains are of nearly equal magnitude, and among them the eye readily distinguishes two minerals: one of a light brown colour and with very distinct cleavage, the other transparent and with a strong vitreous lustre. Further microscopic and chemical examination revealed the presence of three more ingredients: a yellow silicate rarely met with and forming grains, 0·1 mm. across, which exhibit doubly refractive power and appear to crystallise in the rhombic system; they are probably bronzite. Magnetite and magnetic pyrites were likewise present.

An augitic mineral, the one above alluded to, forms the chief mass of the stone; it has a greyish-brown colour, and exhibits double refraction with slight pleochroism. The cleavage and optical characters suggest its classification with diopside. The analytical results given below, however, show that it cannot be regarded as a member of the augite group:

Silicic acid	52·34
Alumina	0·25
Iron protoxide	23·19
Magnesia	14·29
Lime	10·49
	100·56

These numbers accord with the formula:

$$CaO, 2\,MgO, 2\,FeO, 5\,SiO_2.$$

A mixture of hypersthene and hedenbergite, the former greatly preponderating, possesses such a composition. Tschermak finds, however, that the silicate cannot be thus constituted, and he considers this augitic constituent of the Sherghotty meteorite to be a chemical compound which has not yet been discovered in our terrestrial rocks.

The second constituent of this stone occurs more sparsely in transparent colourless granules with vitreous lustre and conchoidal fracture; they proved to be distorted octahedra. "Maskelynite," as Tschermak has named this mineral, does not doubly refract light, and agrees in point of composition with no known cubic mineral, approaching nearest to a labradorite from Labrador examined some time since by Tschermak. The composition of this mineral is:

Silicic acid	56·3
Alumina	25·7
Lime	11·6
Soda	5·1
Potash	1·3
	100·0

In comparing maskelynite with labradorite, or suggesting a possible dimorphism of labradorite, the one form triclinic, the other cubic, the fact must not be lost sight of that labradorite already represents a mixture of two silicates, anorthite and albite, which substances, it will have to be assumed, are dimorphous and occur as a mixture in the cubic form. The action of acid on maskelynite pointed to its composite nature, to the possibility of its consisting of an aluminous silicate containing soda which is less readily acted upon than another aluminous silicate containing lime.

Tschermak represents the Sherhgotty meteorite as made up of:

	Pyroxene.	Maskelynite.	Magnetite.	Total Composition (Calculated).	Total Composition (Observed).
Silicic acid ..	38·21	12·68	——	50·89	50·21
Alumina	0·18	5·79	——	5·97	5·90
Iron protoxide	16·93	——	——	16·93	17·59
Magnesia... ...	10·43	——	——	10·43	10·00
Lime	7·65	2·60	——	10·25	10·41
Soda	——	1·14	——	1·14	1·28
Potash	——	0·29	——	0·29	0·57
Magnetite ...	——	——	4·50	4·50	4·57
	73·40	22·50	4·50	100·40	100·53
Specific gravity...	3·466	2·65	5·0	3·285	3·277

While the Sherghotty stone by its peculiar constitution defies in a way proper classification, it finds a place among the small group of eukritic meteorites, and resembles most closely that of Petersburg (1855, August 5th).

Found 1866.—Frankfort, Franklin Co., Kentucky.
[Lat. 38° 14′ N.; Long. 80° 40′ W.][1]

This block of meteoric iron, which was found on a hill 8 miles S.W. of Frankfort, was conveyed to a blacksmith's forge in that town, in order to test its quality as iron. It weighs 24 lbs., has a somewhat globular form and a highly crystalline structure. The specific gravity of this iron is 7·692 and the composition:

Iron = 90·58; Nickel = 8·53; Cobalt = 0·36; Phosphorus = 0·05; Copper, trace. Total = 99·52.

(To be concluded in our next Number.)

NOTICES OF MEMOIRS.

Paper Read before the British Association at Bristol, August, 1875, Section C. Geology.

I.—On the Distribution of the Graptolites in the Lower Ludlow Rocks, near Ludlow. By John Hopkinson, F.L.S., F.G.S.

THE author first drew attention to the special interest attaching to the Ludlow Rocks, in connexion with investigations on the vertical distribution of the Graptolites, as being the formation in which they apparently die out.

The Rhabdophora or true graptolites, which with the Cladophora or dendroid forms, are found in infinite variety when they first appear in the Arenig rocks, genera the most complex coming in simultaneously with simpler forms, were stated to be represented in the Lower Ludlow rocks by but a single genus, *Monograptus;* and the Cladophora also by one genus only, *Ptilograptus.*

[1] J. L. Smith. *Amer. Jour. Sc.*, 1870, xlix. 331.

A list of the graptolites of the Ludlow rocks given in a former communication to the British Association (1873) was then referred to,[1] and the main conclusions as to the distribution in these rocks near Ludlow of the species enumerated, arrived at in the course of a few days spent in this neighbourhood before the opening of the present meeting, were given.

It was shown that several species of *Monograptus* abound in the lowest beds of the Lower Ludlow; that some of these pass up and a few others come in a little higher in the series, all in soft calcareous sandy shales; and that when a decided change in the strata takes place, indicating in some places, by more siliceous and gritty beds, comparatively shallow water deposits, and in others, by excessively hard fine-grained limestones, a deeper sea, a decided change in the graptolite fauna occurs, the gritty beds containing in myriads a single new form, *Monograptus Leintwardensis,* and the indurated limestone alone yielding the few species of *Ptilograptus* which have yet been detected. *Monograptus colonus,* Barrande, a form first seen in the Llandovery rocks, appeared to be the only species which survived these physical changes, it having alone been seen in the softer beds high in the Lower Ludlow, and passing up from these into the harder calcareous shales which in some places immediately underlie the Aymestry Limestone, and again passing up into this limestone bed, in which it seems finally to disappear.

The author concluded by showing the dependence of the fossil fauna and flora of these rocks on the physical conditions of the Lower Ludlow seas, the fossils frequently being only locally distributed, and varying slightly in their horizons according to the nature of the sediment deposited, the graptolites especially being influenced by these changes, to which their final extinction, or at least their dispersion from the area under consideration, was considered to have been most probably due.

To the list previously given, a single species only, *Monograptus Roemeri,* Barrande, occurring in the lowest beds of the Lower Ludlow, is added by these recent researches.

II.—On the Association of the Native Platinum of the Urals.

M. DAUBRÉE, in an interesting paper read before the Academy of Sciences, has shown that Native Platinum, although obtained abundantly in the alluvial deposits of certain regions of the Ural, has been found in a Peridote (Olivine) rock, which is more or less altered into serpentine, and accompanied with diallage (a ferruginous sahlite, according to M. Des Cloizeaux), and also with chromite, which occurs abundantly, not only in separate grains, but also encrusting the grains of platinum. The platinum, which is here associated with chromate of iron, appears to be distinguished from the platinum of other deposits by the large proportion of metallic iron with which it is alloyed. It appears that platinum very rich in iron, and endowed with magnetic polarity, has not been found—at least, at present—save in company with chromate of iron.—"*Comptes Rendus,*" t. lxxx. —March, 1874.—J. M.

[1] See Geol. Mag. Vol. X. p. 520.

REVIEWS.

I.—Geological Survey of Victoria, No. 2.

1. Report of Progress. By R. B. Smyth. Melbourne (no date).
2. Prodromus of the Palæontology of Victoria. By Fred. McCoy. Decades I. and II. Melbourne, 1874–75.
3. Observations on New Vegetable Fossils of the Auriferous Drifts. By Baron F. von Mueller. Melbourne, 1874.

WE have already noticed the first report of the Geological Survey of Victoria (Geol. Mag. 1874, Decade II. Vol. I. p. 416), and the works above cited sufficiently indicate the satisfactory progress that is being made by the Survey under the direction of Mr. R. Brough Smyth and his able colleagues; while the determination of the animal and vegetable fossil remains could not be placed in better hands than those of Prof. McCoy and Baron Mueller, whose contributions are not only of importance to the Colony, but of equal interest to European geologists.

Mr. Smyth's Report is both suggestive and useful, as it embodies the general results of the explorations of the officers of the Survey during the past year, and whose detailed reports are given in the memoir. From this it appears that the surveying and mapping of the several areas referred to in the last Report are proceeding satisfactorily. The map of the Ballarat gold-field, embracing an area of 160 square miles, with illustrative sections and copious notes, is printed and published. The geological sketch-map of Cape Otway district, comprising an area of about 690 square miles, is ready for issue; and a similar map of South-Western Gippsland will shortly be completed by Mr. Murray, including an area of 3500 miles—a work of time and labour, the country in many parts being so densely wooded as to render the passage difficult.

Satisfactory progress has been made in the survey of the area including the gold-fields of Stawell by Mr. Taylor, and also of the Ararat gold-fields by Mr. Krausé, who gives some interesting geological notes as to the conditions under which the various gold-drifts and associated volcanic rocks were accumulated. The geological map and sections of part of the Mitchell River division of the mining district of Gippsland have been prepared by Mr. A. Howitt, whose notes on the geology of this and the Ovens district (pp. 59–82) are important. The report of Messrs. Etheridge, Junr., and Murray on the country intersected by the Durham *lead* is of much interest.

In this district the Lower Silurian is the bed rock, covered in some places (the south-westerly portion) by Miocene strata, which are non-auriferous; in others, the *Older Pliocene* sands and gravels repose on the upturned surface of the Silurian, and are succeeded by deposits containing gold due to fluviatile denudation, and referred to the *Lower Newer Pliocene*; this river deposit forming the "deep lead" became partially covered by a lava-stream. Denudation again set in, forming another *lead*, and covered by a second flow of lava classed as the *Middle Newer Pliocene*. A series of volcanic eruptions followed more or less contemporaneous, covering up nearly the whole surface of the country. Again denudation set in, scooping out the river-channels of the present period, and leaving along their courses, deposits of gravel and clay referred to the Upper Newer Pliocene.

These Reports, with their respective fine geological maps and sections, a map of the distribution of the forest trees, and the geological sketch-map of Victoria, are highly creditable to the Mining Department, and must materially assist and advance the mining industry of the colony. For as the Report states, "In our quartz-veins we have inexhaustible sources of wealth; and enterprise, skill and economy will assuredly, if mining industry be not checked, place Victoria, as regards vein mining, far in advance of all other countries. The area of auriferous ground, but not in all parts containing gold in such quantities as to remunerate the miner, is not less than forty thousand square miles. The ores of iron—micaceous iron ore and brown hæmatite—are widely distributed, and at no distant period the colony should be enabled to supply its own wants, and there is a reasonable prospect of a large return from at least those districts in which tin, copper, antimony, iron, and lignite are found, the latter occurring in beds of considerable thickness and excellent quality at Lallal and other localities."

The Decades prepared by Prof. McCoy are intended in the first place to give figures and descriptions of the more characteristic fossils of each formation of which good specimens exist in the National Collection, and in future to illustrate the fossil collections made in the course of the Geological Survey of the Colony. The present numbers include detailed descriptions of many interesting fossils,—of Plants, Mammals, Fishes, Mollusca, Starfish, and Graptolites, the species of Graptolites from the Victorian Gold-field slates being similar to those occurring in the Lower Silurian or Cambrian rocks of Bohemia, Britain, Sweden, and America, showing a world-wide distribution of these species in the old geological time. Baron von Mueller's observations on the new vegetable fossils are singularly interesting, as indicating the vegetation of the period when the older auriferous drifts were deposited; they were noticed in a communication to the Geological Society (Geol. Mag. Vol. VII. p. 390, 1870), but are now fully illustrated in ten lithograms, with detailed descriptions and comparisons of their affinities. They were chiefly obtained from the deep drifts of the older Pliocene formation of Haddon, etc., Victoria, but have recently been found elsewhere, and thus, as Baron Mueller remarks, "the discovery of these remains in a far distant tract of country in New South Wales is not without considerable interest, inasmuch as thereby now is shown, that the pristine forests which have left us those vestiges were of wide geographical extent." As far as the Tertiary flora has been examined, there appear to be three periods in which the plants of the lowlands of Victoria were certainly in all respects different. First, the present period, characterized by an abundance of myrtaceous plants; secondly, the period of the deep *leads*, when the plants were of a tropical and sub-tropical character; and thirdly, the period of the Lower Upper Pliocene Tertiaries, when lauraceous plants, etc., were existing. (Report, p. 28.) In conclusion, we agree with Mr. Brough Smyth that "it is impossible to conduct a geological survey without the aid of the palæontologist: and such aid, to be of the highest use and value, necessarily requires that all the fossils should be figured and correctly described." J. M.

II.—The Culm-Flora of the Moravian-Silesian Roofing-Slates. Die Culm-Flora des Mährisch-Schlesischen Dachschiefers. By D. Stur, pp. 106, with 17 plates. Being No. 1. of vol. viii. of the Abhandlungen der K. K. Geologischen Reichsanstalt. Vienna, 1875.

THIS important memoir throws much light upon a point in the geology of Central Europe which until recently was almost a blank as far as accurate knowledge was concerned. As late as 1859 Ferd. Roemer described the great rock-series whence the fossil plants so splendidly illustrated in the plates before us were derived, as "a shapeless inarticulate mass," in which no organism had up to that time been detected. That this series consisted of slate and sandstone, and that it lay conformably upon a far-stretching "grauwacke" formation, which in its turn rested immediately upon the old crystalline rocks of the Sudetic Mountains and upon the flanks of the "Brünn-Blansko" Syenite range, thus covering a considerable portion of Moravia and Silesia (Austrian), was about all that was known respecting it. In 1860 Roemer himself wrung the first secret from these beds by discovering in them a locality for *Posidonomya Becheri.* From that date progress was made through the labours of Roemer, H. Wolf, Halfar, von Ettingshausen, von Hochstetter, and especially of Herr Max Machanek, the manager of slate quarries in the district, to whose zeal in collecting a large proportion of the species described by Prof. Stur is due. It was found that here were Carboniferous rocks lying upon Devonian beds, from which they were quite undistinguishable except palæontologically, and that further these Carboniferous roofing-slates and grits could be referred to the *Posidonomya-schiefer* or *Culm*-formation of Nassau and Western Westphalia. The divisions now recognized in the Culm of Moravia and Silesia are three in number, and are characterized as follows:

1. The westernmost and lowest zone, which lies directly upon the Devonian series, and comprises the two older varieties of roofing-slate. It is from 3000 to 4000 fathoms (Klafter) thick, and consists of sandstones, slates (Klotzschiefer), and yellowish fine-grained conglomerates yielding good building stone.

2. The middle zone, 4000 to 5000 fathoms thick, is composed of similar rocks to the last, but the enclosed slates are of the thin-splitting kind known as Blattelschiefer.

3. The upper zone, also about 5000 fathoms thick, is the least studied of the series, and is distinguished by a fine deep blackish-blue Blattelschiefer.

The fossils hitherto found in these divisions are thus distributed :

	Zones. 1	2	3
FAUNA.			
Phillipsia latispinosa, Sandb.		x	
Ph. sp.			x
Nautilus sp.		x	
Goniatites prior, Stur.	x		
G. Machaneki, Stur.		x	
G. sphæricus, de Haan.		x	
G. cf. discus, A. Roem.		x	
G. mixolobus, Phill.		x	
Cyrtoceras Machaneki, Stur.		x	
C. rugosum, Flem.		x	
Gomphoceras scalariforme, Stur.		x	
Orthoceras cf. scalare, Goldf.		x	
O. striolatum, H. v. M.		x	
O. costellatum, A. Roem.		x	
Euomphalus sp.		x	
Posidonomya Becheri, Br.	x	x	
Inoceramus sp.		x	
Pecten subspinulosus, Sandb.		x	
P. Roemeri, Stur.		x	
P. sp.		x	
Lophocrinus speciosus, H. v. M.		x	
Nemertites Sudeticus, Roem.	x	x	
Crossopodia Moravica, Stur.	x		
FLORA.			
Drepanophycus Machaneki, Stur.		x	
Equisetites cf. mirabilis, Stur.	x		
Archæocalamites radiatus, Stur.	x	x	x
Thyrsopteris schistorum, Stur.		x	
Sphenopteris foliolata, Stur.		x	
Sph. distans, Sternb.		x	
Sph. divaricata, Goepp.		x	x
Sph. Falkenhaini, Stur.			x
Sph. striatula, Stur.			x
Sph. Ettingshauseni, Stur.		x	
FLORA—continued.			
Sph. Haueri, Stur.		x	
Sph. Kiowitzensis, Stur.			x
Rhodea filifera, Stur.		x	
Rh. Machaneki, Ett. sp.		x	
Rh. Hochstetteri, Stur.		x	
Rh. gigantea, Stur.		x	
Rh. patentissima, Ett. sp.		x	
Rh. Moravica, Ett. sp.		x	x
Rh. Goepperti, Ett. sp.		x	
Cardiopteris frondosa, Goepp. sp.		x	x
C. Hochstetteri, Ett. sp.		x	
Neuropteris antecedens, Stur.		x	x
Archæopteris Tschermaki, Stur.		x	
A. Dawsoni, Stur.		x	x
A. dissecta, Goepp. sp.		x	
A. lyra, Stur.		x	
A. pachyrhachis, Goepp. sp.		x	
Adiantites tenuifolius, Goepp. sp.		x	
A. antiquus, Ett. sp.		x	
A. Machaneki, Stur.		x	
Cycadopteris antiqua, Stur.		x	
Todea Lipoldi (Goepp. MS.) Stur.			x
Rhacopteris paniculifera, Stur.		x	
Rh. Machaneki, Stur.		x	
Rh. flabellifera, Stur.		x	
Rh. transitionis, (Ett.) Stur.		x	x
Stigmaria inæqualis, Goepp.	x	x	
Lepidodendron Veltheimianum, Sternb.	x	x	
Halonia tetrastycha, Goepp.		x	
Walchia antecedens, Stur.		x	
Pinites antecedens, Stur.		x	
Rhabdocarpus conchæformis, Goepp.	x	x	

Although it has not hitherto been found in Moravia nor in Austrian Silesia, yet *Productus giganteus* is well known in the Culm deposits of Rothwaltersdorf in Lower or Prussian Silesia, between which and Zone 2 of the Sudetic Culm there is much in common.

The plants which are enumerated above, and which form the special object of Prof. Stur's memoir, are fully described and most beautifully figured in the numerous plates of this handsome work.

G. A. LEBOUR.

CORRESPONDENCE.

"WULFENITE" AT "CALDBECK FELL."

SIR,—As Wulfenite has hitherto been recorded from only one locality in the British Isles, viz. Lackentyre in Kirkudbrightshire, it may interest some of the readers of the GEOLOGICAL MAGAZINE to learn that it has lately been found at one of the Caldbeck Fell mines, in Cumberland, associated with Pyromorphite, Anglesite, and various other ores of Lead. As Molybdenite is rather common in some of the adjoining mines, the occurrence of Molybdate of Lead might, perhaps, have been expected, as a result of the decomposition of Molybdenite and Galena.

Another mineral new to the British list has just been detected in the Hæmatite mines of the Cleator district. This is Hausmannite, which occurs, well crystallized, in small pockets and veins associated with Pyrolusite, mostly between the hæmatite and the limestone in which it is found.

Further notices of these minerals will appear in the Memoirs of the Geological Survey. J. G. Goodchild.

Penrith, *9th October*, 1875.

PRISMATIC STRUCTURE OF BASALT.

Sir,—Assuming the description of the three basaltic prisms in the collection of the Geological Society as given by Mr. Scrope to be exact (see Geol Mag. 1875, Decade II. Vol. II. p. 412), the facts do not in any way conflict with the explanation that I have given of the mode of production of the lenticular cross-joints in basaltic prisms. The prisms referred to must have come from that part of the original mass in which occurred the dividing surface between that part cooled from the top and that cooled from the bottom of the mass, as is proved with respect to one of the prisms by the existence in it of a joint having surfaces concave in both directions, such plane in fact passing horizontally through this articulation; other adjacent prisms may have their joints, within certain limits above or below this plane, either convex upwards or downwards, for the slightest differences in the conductivity or conditions and rates of cooling will suffice either to depress or elevate, by a greater or less distance, the plane already spoken of. It is also not difficult to see that several alternations in the directions of the concave or convex surfaces may occur in the neighbourhood of the meeting plane of cooling in opposite directions, where, as in the case of other divergent or opposite heat waves, more or less confusion in normal structure must occur.

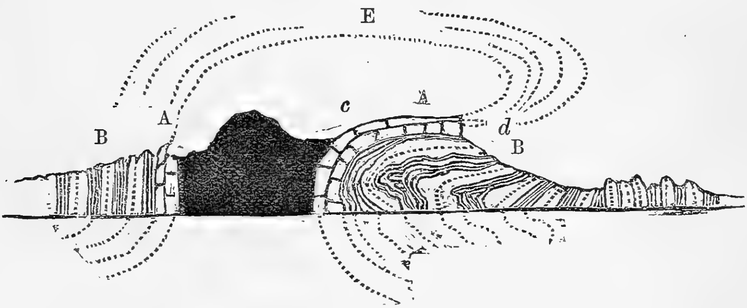
18th October, 1875. Robt. Mallet.

THE INVERTED STRATA OF THE MENDIPS.

Sir,—Referring to Mr. A. M'Murtrie's interesting paper "upon certain isolated areas of Mountain Limestone at Luckington and Vobster" (read in Section C. of the late Meeting of the British Association at Bristol), wherein he showed these isolated patches to have been passed beneath and found separated from any underlying portion of the same limestone, it occurred to me at the time that the structural peculiarities of certain places I had examined would tend to explain those described in the paper, the whole of which I had not the good fortune to hear read, and therefore refrained from offering the following remarks in the Section.

It appeared that along the Luckington and Vobster side of the Mendip Hills, the abnormal inverted or apparently discordant junction of the disturbed Coal-measures at their foot, with the limestones of the range, is traceable for about five miles, two of the three outlying, and, as I could gather, inverted patches of limestone being situated at distances from the junction of somewhat more than a mile and a little less than three-quarters of a mile respectively. The hypothesis that these outliers were portions of underlying limestones brought to the surface by faulting, having been set aside by the fact of the outliers' non-continuance in depth, the author favoured the idea of inversion instead.

That such an amount of inversion as Mr. M'Murtrie suggested is by no means an impossibility I can well conceive, having seen, in the case of a narrow and much compressed anticlinal ridge, on the confines of Afghánistán, a strong band of hard limestone with a great thickness of overlying sandstones and clays, so completely inverted that this limestone band could be traced curving upwards and outwards from its place on the flank of the anticlinal, until found to rest for nearly half a mile with completely inverted horizontality upon the likewise inverted sandstones and clays, the whole of the rocks being well exposed, and the inverted limestone capping spurs from the anticlinal range, thus:—



A. Limestones. B. Sandstones and Clays. *c. d.* Inversions of varying width up to above ¼ mile or nearer half a mile English.

In the country where this occurs nearly all the boundaries of numerous parallel anticlinal ridges are lines of abnormal vertical or inverted junction of the two groups represented above, these ridges having lengths sometimes exceeding fifty miles, and the only places where the rocks are found in their, so to speak, natural or normal order being where the beds fold over the terminations of the anticlinal axes.

Such lines of abnormal junction or inversion are also known to exist for greatly longer continuous distances on the flanks of the Himalayas and the Alps.[1]

But admitting inversion in the case of the Luckington and Vobster

[1] See paper on the Alps and Himalayas, by H. B. Medlicott, Esq., Quart. Journ. Geol. Soc. 1868, vol. xxiv. p. 34, and a paper On Some Points in the Stratigraphical Structure of the Panjáb, *op. cit.* 1874, vol. xxx. p. 61.

outliers, the steps by which the isolation and removal of these patches to a distance was accomplished remain to be traced; and here, perhaps, without undue exercise of imagination where evidence is wanting, it may be suggested that after inversion the adjacent face of the Mendips might have assumed the form of a high escarpment made up of the softer Coal-measures capped by the overthrown limestones, when land slippage, during the wasting backwards of the escarpment, might have taken place, allowing large masses of the harder rocks above to subside; or a succession of landslips might each be accompanied by an outward as well as a downward movement.

In support of this suggestion, I may mention an escarpment some 1500 to 2000 feet in height, with which I am acquainted, composed of various soft and more consistent beds below, capped by unusually hard and massive ones above. Along this scarp land-slippage has taken place to such a degree that great detached masses of the upper sections have settled down on the sloping outcrop of the softer beds, until they have, in several instances, arrived by combined processes of slipping and weathering back at distances from their main outcrop quite comparable with those of the outliers in question from the suggested escarpment of inverted beds. Some of these detached masses exceed the dimensions of the Upper Vobster outlier; and, so far as can be judged without having seen the locality, there appears to be no insuperable difficulty in accounting for the position of these outliers in this way.

It should be noticed in connexion with the subject of such great inversions, that disruption or faulting may have accompanied the distortion of the anticlinal arches, permitting the inverted strata to fall away, or else the whole set of beds, including both the limestones and those above them, must be supposed to have turned back upon themselves again, as shown in the figure at E. No instance, upon a large scale, in which this is proved to have occurred, has fallen within my experience, though some sections have suggested it, and in the absence of such recurvature, displacement amounting to faulting may, after all, have been a necessity in some part of the process by which these features were produced.

ए. ब. व.

ON THE NOMENCLATURE OF ROCKS.

Please correct the following in the GEOLOGICAL MAGAZINE for September:—

Page 426, *line* 22, in two places, trach*ylyte* for trachalite.

G. H. KINAHAN.

BOULDER-CLAY IN IRELAND.

SIR,—I can assure Mr. Birds that it is perfectly incorrect to suppose that an Upper Boulder-clay in Ireland *resting on "middle sands and gravels" has been proved in any place.* Normal Boulder-clay has been found in many places resting on sands and gravels, but the latter cases are of an age prior to the accumulation of the Glacial Drift of that country. Some of these old sands and gravels have been made to do duty for the "middle sands and gravels," while in other places the so-called "Upper Boulder-clay" is a glacialoid drift, a meteoric drift, or an aqueous drift, in which a few blocks or fragments of stone can be found, still retaining some ice-scratches.

WEXFORD, *October* 5, 1875. G. HENRY KINAHAN.

FORMATION OF A MINERALOGICAL SOCIETY.

SIR,—An effort is being made for the establishment of a Mineralogical Society of Great Britain and Ireland. Will you permit me to call the attention of your readers to this fact, and to say that I shall be happy to give information on the subject to any persons who may desire to become members.

The objects of the Society are—

To simplify Mineralogical Nomenclature.

To determine and define doubtful mineral species.

To study the *Paragenesis* of minerals.

To record instances and modes of pseudomorphism with their accompanying phenomena.

To measure, determine, and illustrate forms of crystallization, especially the irregularities and peculiarities of particular planes, or of crystals from particular localities.

To discuss systems of classification, and to establish a natural system.

To collect, record, and digest facts and statistics relating to economic mineralogy.

To promote the exchange of specimens; and, generally,

To advance the Science of mineralogy.

The rules and regulations to be ultimately adopted will be decided upon by the votes of probably the first 100 members.

57, LEMON STREET, TRURO, J. H. COLLINS.
September 17*th*, 1875.

ORIGIN OF ESCARPMENTS AND CWMS.

SIR,—Several years ago you kindly published a number of articles by me on Denudation, and likewise the answers they elicited from several well-known geologists. The substance of these articles was afterwards incorporated with my work entitled "Scenery of England and Wales, its Character and Origin," in which, among other subjects, I entered into a detailed consideration of the origin of escarpments and cwms, especially the very typical cwms of North Wales. Since then Mr. Kinahan has written a work on the Surface-geology of Ireland, which to a great extent is a repetition in different words of the kind of arguments I adopted in reference to England and Wales; and Mr. Goodchild in several recent articles in the GEOL. MAG. has (evidently without being aware of what I had written) not only used many of my arguments against Subaërialism in substance, but, in several cases, coincidentally expressed them in nearly the same words. This will be seen from a comparison of some portions of Mr. Goodchild's articles with the following quotations from my work on England and Wales:—"Carrying away the blocks and fragments, the removal of which must, in a general way, have kept pace with the recession of the cliffs. . . . . the power of a moving crust of land-ice several thousand feet thick to excavate cwm-shaped hollows.....could only have done so on meeting with an obstruction such as a steep slope which would deflect the current of ice, and make it acquire a gyratory motion which would enable it to scoop out semicircularly backwards, and possibly at the same time downwards..... To be a cwm a hollow must be approximately curvilinear. Rain is doing all it can to destroy this curvilinearity. Rain-streamlets in cwms are gullying their brims and channelling their sides. A continuation of the process would render a cwm a mere confluence of ravines. The chipping action of frost, aided by rain, is tending to reduce the steepness of the encircling cliffs by bevelling off their upper parts, and hiding their bases under screes. Rain in a state of dispersion is possessed of so little power that it cannot keep up a uniform abrasion of the sides of cwms so as to preserve their curvilinearity..... If a single stream cannot produce a cwm, several streams cannot combine so as to give rise to a cwm. ....Springs would be incapable of undermining laterally so as to leave a hollow at all approaching to the breadth of an average cwm, while a spring undermining backwards would leave a ravine, not a cwm.....Springs and streams are the effects instead of the cause of cwms..... What is the stream now doing in the upper part of its course, for instance under Glaslyn [Snowdon]? Merely rutting a continuous face of rock." The above are only a few quotations selected from many passages to the same effect. I have likewise, in articles in the GEOL. MAG., etc., frequently referred to the evidences furnished by glaciated rock-surfaces in peculiar positions, and by the undisturbed curvilinearity of *eskers*, of the very small influence exerted by rain and freshwater streams since the Glacial period. While, however, agreeing with much that Mr. Goodchild has written, I cannot help differing from him on many points—such, for instance, as the forms he assigns to the traces of sea-action; but I fear I have already trespassed too much on your increasingly valuable space.

D. MACKINTOSH.

"BOTTLEITE."[1]

SIR,—It gives me great pleasure to find that Mr. G. H. Kinahan admits that the curious black mineral called "Bottleite," attached to the base of some layers of granite, "seems due to crystalline structure, the substance being deposited from solution." (See his letter GEOL. MAG. for September last, p. 426.) As I have long held that Flint is stalactitic, so I feel certain is Bottleite, a siliceous "stalactite" which has dripped, so to speak, out of the granite.

Whatever Bottleite and Flint are, Obsidian and Isopyre must be classed with them.[2] More information is anxiously looked for by Yours, etc.

M. B. ALDER.

FERN BANK, HOLYWOOD, CO. DOWN.
Sept. 22nd, 1875.

[1] Mr. Allport, F.G.S., remarks: "'bottleite' and 'trachalite' are synonymous, 'bottleite' being the local name for a vitrioid rock pronounced to be 'trachalite.'"—EDIT. GEOL. MAG.

[2] We venture to suggest that Miss Alder has opened a wide field of inquiry for Mr. Collins's proposed New Mineralogical Society. (See *ante* p. 569.)—EDIT. GEOL. MAG.

OBITUARY.

FREDERICK ERASMUS EDWARDS, F.G.S.,

BORN OCTOBER 1, 1799, DIED OCTOBER 15, 1875.

Some five-and-thirty years ago, a little society was founded by a few London geologists, namely, Dr. J. S. Bowerbank, F.R.S., F.L.S., F.G.S., Searles V. Wood, F.G.S., John Morris, F.G.S., Alfred White, F.L.S., Nathaniel T. Wetherell, F.G.S., James de Carle Sowerby, F.L.S., F.Z.S., and Frederick E. Edwards, F.G.S., for the purpose of illustrating the EOCENE MOLLUSCA, and entitled "The LONDON CLAY CLUB."

Who would have supposed that this society, so small and unpretentious in its outset, should have given birth to one of the most useful and valued scientific societies in London? the PALÆONTOGRAPHICAL SOCIETY, which has now existed for twenty-nine years, and numbers more than 350 members! A society which has produced 28 huge annual quarto volumes, containing 7840 pages of letterpress, and illustrated by 21,773 figures of 4273 species: not confined, like the original enterprise, to the illustration of the London Clay Mollusca, but aiming eventually to accomplish the task of illustrating all the fossil remains found in the British rocks!

Of the seven geologists who founded the old "London Clay Club," five still survive, namely:

Dr. J. S. Bowerbank, F.R.S., F.L.S., F.G.S., Pres. Pal. Soc.; Searles V. Wood, F.G.S., Treas. Pal. Soc.; Prof. Morris, F.G.S.; Alfred White, F.L.S.; Nathaniel T. Wetherell, F.G.S.

James de Carle Sowerby died in 1871,[1] and we have now the sad task to record the loss of another of these early workers in palæontology, that of FREDERICK E. EDWARDS, the historian of the Eocene Tertiary Mollusca.

Brought up to the profession of the law, and filling the responsible post for more than forty years of chief clerk to Masters Wingfield and Blunt, and to Vice-Chancellors Kindersley and Malins, he devoted his entire leisure time to the collection and study of the Mollusca of the Eocene Tertiaries of England.

1. His earliest contribution appeared in the "London Geological Magazine," for September, 1846, edited by E. Charlesworth, F.G.S., "On the Eocene *Tellinæ*," and at a later date, at intervals, in the monographs of the PALÆONTOLOGICAL SOCIETY appeared:

2. In 1848, "The Eocene Mollusca," Part I. CEPHALOPODA (with nine plates).
3. In 1854, " " " Part II. PULMONATA (with six plates).
4. In 1854, " " " Part III. No. 1, PROSOBRANCHIATA (with eight plates).
5. In 1855, " " " Part III. No. 2, PROSOBRANCHIATA *continued* (with four plates).
6. In 1858, " " " Part III. No. 3, PROSOBRANCHIATA *continued* (with six plates).

[1] See Obituary Notice of Mr. Sowerby, GEOL. MAG. 1871, Vol. VIII. p. 478.

7. "Notice of the Fossil Remains of a New Freshwater Mollusc from the Lower London Tertiaries," in the "Geologist," 1860, vol. iii. p. 208, pl. v.
8. "Descriptions of Some New Eocene Species of *Cypræa* and *Marginella*," in the GEOL. MAG. 1865, Vol. II. p. 536, Pl. XIV.

It is an unfeigned source of regret to all workers in Eocene geology that after this date, owing to his failing health, Mr. Edwards ceased to publish the results of his long and careful examination of his great collection, the formation of which occupied the greater part of his lifetime.

His friend Searles V. Wood, F.G.S. (Treasurer of the Palæontographical Society), well known for his valuable monographs on the Mollusca of the Crag, took up the "Eocene Bivalves" in 1859, in 1862, and again in 1870, publishing three parts, illustrated by 25 plates; but much yet remains to be done in order to complete the entire series.

Fortunately for science, Mr. Frederick Edwards's magnificent collection, contained in five large cabinets, has been acquired by the Trustees of the British Museum, and now forms a part of the National Collection; as also does a part of the fine series of Eocene Mollusca obtained by N. T. Wetherell, Esq., F.G.S., from the neighbourhood of Highgate.

In future, students of Eocene Fossil shells may avail themselves of the advantages which these valuable collections afford them for purposes of scientific work.

Though often harassed by family cares and anxieties, and oppressed with the responsibilities of his official work as a solicitor, daily occupied in hearing and adjudicating upon difficult cases in Chancery, in private life Mr. Edwards was nevertheless greatly beloved by those who knew him intimately, and, when his health permitted, he delighted to gather his geological brethren around his table, and revive in his later years those pleasant social and quasi-scientific reunions which formed the bond of cohesion among the members of the old "London Clay Club."

J. M. AND H. W.

MISCELLANEOUS.

OOLITIC BRACHIOPODA.—Mr. J. F. Walker, M.A., F.G.S., exhibited at the last meeting of the Yorkshire Naturalists' Club, the following species of Brachiopoda which occur on the Continent, but are scarcely known as British species, viz. *Terebratula bisuffarcinata,* Schlot., and *Rhyn. Thurmanni,* Voltz., from the Lower Calcareous Grit of Filey, Yorkshire Coast; *Waldheimia umbonella,* Lamarck, from the Kelloway Rock of Scarborough; *Terebratula Eudesii,* Oppel, and *Terebratula ventricosa,* Yieten, from the Inferior Oolite of Cheltenham; and *Terebratula Ferryi,* Des., from the Inferior Oolite of Dorsetshire.

INDIAN GEOLOGICAL SURVEY.—We regret to learn that Dr. Wm. Waagen, of the Geological Survey of India, has been obliged by ill health to resign the appointment of Palæontologist, his promotion to which we lately noticed.

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

No. XII.—DECEMBER, 1875.

ORIGINAL ARTICLES.

I.—The Cause of the Glacial Period, with Reference to the British Isles.[1]

By Charles Ricketts, M.D., F.G.S.

IT is a fact universally accepted that, within a period comparatively recent, extensive districts in North America and in Europe, now fruitful and luxuriant, were covered with a thick mantle of snow and ice; and their valleys were filled with glaciers, which extended into the sea, and, breaking off at their extremities, floated away as icebergs.

The causes which produced a temperature of such severity, as the evidences upon which this opinion has been founded indicate, have excited much speculation. The theory which of late has found most advocates is that proposed by Mr. Croll:—That the winters during this, the Glacial Period, happened in aphelion, when, as a result of a greatly increased eccentricity of its orbit and the precession of the Equinoxes, the Earth was eight and a half millions of miles further distant from the Sun during winter than it is at present; that therefore the winters would have been longer and the cold more intense; that the North Polar regions were entirely covered with a thick capping of ice, so great that the accumulation caused a displacement of the Earth's centre of gravity; and to this cause he attributes the submergence of the land which is constantly found where evidences of glaciation have been observed. He also justly concludes that the so invariable occurrence of submergence along with glaciation points to *some* physical connexion between the two. But the submergence of Greenland, beneath its present rapid accumulation of snow, cannot be referred to such a cause as a change in the Earth's centre of gravity, for at the same time and in about the same latitudes—in Norway and Spitzbergen—the land is rapidly rising. It seems not improbable that the recent recession of the glaciers in Norway may account for the rise of land there, in consequence of the removal of pressure, and, to a similar cause, its occurrence, subsequent to the Glacial Period, may be attributed.

I have elsewhere (Geol. Mag. Vol. IX. page 119) attributed this subsidence during the Glacial Period to the effects of the pressure which this increased mass of snow would have in forcing downwards the crust of the earth into its fluid substratum; basing my opinion,—upon the constant occurrence during all geological time of evidences

[1] Read before the British Association (Section C.) at Bristol, August, 1875.

of subsidence and accumulation co-existing in the different formations,—on the existence of bays and of deltas at the mouths of all great rivers, being the submerged and filled-up continuation of their valleys; in the latter the result of artesian borings has proved the occurrence at various depths of evidences of what have been successive land surfaces,—on the depression which took place during the Glacial Period, and the partial re-emergence of the land when it was relieved of its weight of ice and snow,—and on the subsidence recently occurring in Greenland simultaneously with a rapid increase of accumulation of snow.

The occurrence of subsidence of land being due to the pressure of accumulations, though it has been advocated by Sir John Herschel, by Prof. Hall of New York, and by Dr. Dawson of Montreal, appears in a singular manner to have escaped the consideration of geologists; though by this circumstance only can a satisfactory explanation be given of many geological phenomena. Nevertheless, the fact of their simultaneous occurrence is constantly recognized.[1]

The relative positions under which the two Poles are placed are so different, that great care must be taken in arguing from the state of one to that of the other. It must not be inferred that because it may be possible that the *land*, situated at the South Pole and surrounded by *water*, is covered with an "ice-cap," that therefore the *ocean*, situated at the North Pole and surrounded by *land*, would be covered in the same way. It appears to be more than doubtful whether, with the existence of an Arctic Ocean having communications open with the Atlantic and Pacific, an "ice-cap" comparable with that covering the land about the Antarctic Pole could by any possibility exist; for before a resting place could be found sufficient to bear such an accumulation of snow, as has been supposed to have at one time existed, the whole sea must have been frozen even to its lowest depths; and that could not take place whilst salt water continues to get denser as it becomes colder, and there is also a free communication between the Polar Sea and the Atlantic.

Nor could there have been, during the Glacial Period, any great thickness of snow on the land surrounding the Arctic Sea; for per-

[1] In the President's Address to the Geologists' Association, Nov. 7th, 1873, Mr. H. Woodward, F.R.S., has objected to the theory of subsidence being the result of accumulation, on the grounds that if in the Bay of Bengal (where, by the artesian borings made in the Delta of the Ganges, the land has been proved to have sunk to the depth of 481 feet and upwards) the sediment deposited has power by gravitation to thus depress the ocean-bed, much more ought the solid mass of the Himalayan range, with its innumerable and lofty peaks, to sink into the yielding crust beneath (Geol. Mag. 1873). But the areas out of which the Himalayas have been sculptured have, from the commencement of their present denudation, been sustained above the sea-level, and the weight to be supported has diminished, as particle after particle has been removed, the peaks and valleys registering a portion, but by no means the greater amount, of the denudation the mass has undergone; so that the Himalayas, in consequence of the great amount of denudation to which they have been subjected, will not press with so great a weight upon the fluid substratum. But if the sediment brought down by the Ganges and Brahmapootra has caused, by its weight that subsidence which has taken place in the Bay of Bengal, it necessarily follows that the area, forming and supporting these mountains, must rise in accordance with the amount of material removed.

petual snow existed as far south as the latitude of New York, and the greater part of Europe was covered with it; the wind passing over a land surface of such extent and having a glacial temperature, would have had almost the whole of its water condensed out of it long before reaching the Arctic Circle. "The wet would be squeezed out by the cold, as water is wrung from a sponge."[1] Even when the winds have to pass over land, the mean temperature of which is considerably above the freezing-point, the air parts with so much of its moisture that at no time, since the Mammoth and woolly-haired Rhinoceros roamed over the plains of Siberia, has there been in Northern Asia so great an accumulation of snow as to form glaciers; otherwise the remains of these animals, found in the banks of the Lena, would have been swept by them into the Arctic Sea; yet during all that time the soil, in which they have been imbedded, has continued so persistently frozen that their remains have been preserved with the soft parts undecomposed.

It does not at all follow that, with diminution of temperature in the Arctic regions, there should also have been at the same time reduction of the winter temperature of the British Isles. The present temperate and equable climate of Britain is dependent on the warmth of the waters which, derived partly from those of the Gulf Stream and at a lower temperature from those of the Temperate Zone, are carried as a set or current towards the Polar regions; and, being many degrees higher than would otherwise be the mean annual temperature of the British seas, modify also the temperature of the air passing over them.

Dr. Carpenter has, as I believe, demonstrated that what I will call the North Polar Current (termed in Johnston's Physical Atlas, "North-East Branch of the Gulf Stream") is dependent on the effects which diminution of temperature in the Polar regions has in causing the displacement by sinking of the surface water of the Arctic Sea, the density of which has been increased by the temperature being diminished, and the necessary influx of lighter water, that is, the comparatively warm water derived from the Gulf Stream and the Temperate Zone, to replace the colder which has subsided.

The North Polar Current thus produced, and consisting of water very much warmer than the surface temperature of the North Atlantic would be, if this current did not exist, supplies heat and moisture to the atmospheric currents passing over it; so that partly on this account, and partly from the inability of heat to radiate so readily from the surface of the land in consequence of the frequent cloudiness of the sky, the winter temperature of Britain is considerably milder than it would be under different conditions; whilst in summer it is often modified by the difficulty with which the sun's rays can penetrate when, from the same cause, there is an excess of cloud or vapour in the atmosphere. If the peninsula of Florida did not exist, the winter temperature of Britain would be still milder, as, in consequence of it, the Gulf Stream has to traverse a distance of several hundred miles more than would be the case otherwise.

[1] J. Campbell, F.G.S. "Frost and Fire."

Changes of climate are now taking place for which I can imagine no adequate cause, excepting the reckless destruction of the great American forests. The temperature of Iceland and of Greenland is much more rigorous than when they were first discovered;[1] whilst, upon the other hand, the glaciers of Norway are receding, and the Christmas of tradition visits us at very distant intervals. Even temporary changes as indicated in North America appear to influence our winters; thus of late years the most severe winters there, such as those of 1872–73 and 1873–74, were with us remarkable for their mildness. The opposite conditions have also been noticed; such as occurred during the Russian War in 1854–55, when the frost on the Eastern shores of the Atlantic was intense, whilst the winter was mild in Northern America. It has been stated that "it is a saying amongst the Danes that there is mild weather in Iceland when it is cold in Europe, and *vice versâ.*"[2]

Previous to the Glacial Period there existed a very different contour of the North American continent from the present. The Gulf of Mexico extended over what is now the valley of the Mississippi, even to St. Louis, upwards of 600 miles north of New Orleans; the peninsula of Florida was submerged; and along the east coast a very considerable belt of land, extending to the Alleghany Mountains, was sunk below the level of a sea whose waters were of a tropical temperature. Such a variation in the coast-line must have had a great effect upon the climate. With a Gulf of Mexico extending 9° farther north than it does at present, the air, heated and charged with moisture derived from its tropical waters, would have been directed up the valley of the Ohio by the western flanks of the Appalachian chain, and have modified the climate even of extreme northern districts. Florida presenting no obstruction, the Gulf Stream must have been impelled many degrees further northwards by the *vis a tergo*—the N.E. and S.E. trade-winds—carrying a larger quantity of Equatorial water than it now conveys, namely, that which is deflected round the western extremity of Cuba and what escapes over the Bahama banks and channels. Therefore the amount of heat derived from the tropics which was conveyed to high northern latitudes must have been immensely increased. I am not aware whether it is possible to co-ordinate those beds abounding in plant-remains, which have been discovered in Greenland, in Iceland, and in Spitzbergen, with those indicating these changes in the coast-line of America; but such alterations must have induced a condition of temperature at all events nearly approaching, if not similar to, that which these plant-remains indicate.

As the present state of the winter temperature of Britain depends on the volume and warmth of the North Polar Current, the waters of which are, to a considerable extent, derived from those of the Gulf Stream, it follows that any serious diversion of this stream would affect our climate in an opposite direction.

There are two areas in the isthmus which separates the Atlantic

[1] A Visit to Iceland. By Madame Ida Pfeiffer. Page 64.

[2] Iceland: its Scenes and Sagas. By S. Baring-Gould. Page xxxi.

from the Pacific where a comparatively slight depression would cause the two oceans to mingle. The Panama Railway cuts through a ridge which is 299 feet above the sea-level;[1] and, near Lake Nicaragua, the lowest pass is 133½ feet above the sea,[2] whilst the isthmus nowhere attains the height of 1000 feet.[3] Should depression take place so as to submerge these areas, there would be no impediment to the Atlantic Equatorial waters passing into the Pacific Ocean, for the mean height of the former is somewhat greater than that of the latter—that is, it is somewhat banked up by the action of the trade-winds.

In considering the West Indian Islands as the remains of a submerged part of the continent of South and Central America, Mrs. Somerville has given the true explanation of the formation of the Gulf of Mexico; but the depression by which they have been formed has extended to a greater depth than the present. In Jamaica the Tertiary strata are more than 5000 feet thick,[4] and Santiago in San Domingo, situated 2000 feet above the sea, rests on Tertiary strata.[5] The whole valley of the Mississippi to beyond its junction with the Ohio once formed a portion of the Gulf of Mexico, the land having sunk considerably below its present level.

Former depression has also taken place along the western coast. Professor Newberry observed a sea-beach, containing shells similar to those now existing in the ocean below, at 80 or 90 feet above high-water mark, and also at a still greater elevation;[6] and the Gulf of California is but a submerged extension of the valley of the Colorado River.

It is not probable that subsidence could have occurred to so great an extent on both its sides without the same process also affecting the isthmus.

The present fauna on the different sides of the isthmus affords indications of a former intercommunication of the two oceans; by the identity of species in some instances, by the similarity in others. Mr. Philip P. Carpenter (British Association Report, 1856) regards 35 species of shells as identical in the two oceans; 34 species are so nearly allied that they may prove to be identical; and 41 species really separated but by very slight differences only. Professor Wyville Thomson, in "Depths of the Sea," arranges side by side 18 Echinoderms from each sea, "which resemble one another so closely in habit and appearance as to be at first sight hardly distinguishable."

There have been few, if any, investigations made for the purpose of determining the question, but these evidences are almost conclusive that submergence of the isthmus has taken place so as to permit

[1] Admiralty Chart.

[2] The Naturalist in Nicaragua. By Thos. Belt, F.G.S. Page 35.

[3] Tertiary Beds in St. Domingo. By T. S. Heneken Quart. Journ. Geol. Soc., vol. vi. p. 44.

[4] Notice of the Geology of Jamaica. By P. M. Duncan, M.B., Sec. G. S., and G. P. Wall, F.G.S. Quart. Journ. Geol. Soc., vol. xxi. pp. 5 and 6.

[5] On Tertiary Beds in San Domingo. From Notes by T. S. Heneken. Quart. Journ. Geol. Soc., vol. vi. page 39.

[6] Colorado Exploring Expedition.—Geology. By Dr. J. S. Newberry. Page 12.

the waters of the two oceans to mingle. If it has occurred to any considerable extent, it must necessarily have progressed in an increasing ratio, unless there were any counteracting forces brought into action; for the causes which induced it would still have been in operation; sediments brought down by the Amazon and Orinoco would still have been carried into the Caribbean Sea, and in much greater quantities, for the Equatorial Current, meeting with no obstruction at the isthmus, would have been propelled with greater celerity by the trade-winds; whilst such portions of the sediments from the Mississippi, as are now carried towards Florida, would have been deposited in the Gulf, and, if the winter climate in the north increased in severity, the amount of these deposits would be augmented, as the frost would disintegrate the rocks more rapidly, and in a greatly increased ratio, if the land was covered with glaciers.

If the temperature of our island can be influenced in any appreciable degree by changes of temperature affecting the Arctic Ocean, the winter temperature would be lowered to an immensely greater extent should any considerable volume of Equatorial water be diverted across the supposed submerged isthmus, for the hottest of the water would pass into the Pacific Ocean; whilst according to the size and depth of this diverted current, the Gulf Stream in the Atlantic would become less and less, in consequence of the diversion of that force by which it was impelled forward.

With an indentation of Central America similar to the present, there could, under no circumstances, have been the same amount of warmth conveyed to such high southern latitudes by the Brazilian Current as now passes to the north by the Gulf Stream, for, not only the whole of the northern division of the Equatorial Current must have been propelled into the Caribbean Sea, but a considerable amount of the southern division also, from which, on account of the obstruction caused by the south-east trade-winds, there would be no method of escape southwards, and therefore it must have been borne towards the north, as it is now by the Gulf Stream. But should there have been depression of the isthmus, not only would there have been, as we have seen, reduction of temperature in the North Atlantic, but in the South Atlantic also; for if it were not for the obstruction caused by the isthmus, the power and extent of the Brazilian Current would be much decreased, in consequence of the greater portion, and that the hottest, of the southern division of the Equatorial Current continuing onwards past Cape St. Roque, so much of it not being deflected along the east coast of South America as there is now.

If this submergence of the isthmus has taken place, and it is the necessary result of those changes which were in progress during the Tertiary Period, the extension of the Gulf of Mexico northward would still have continued, as it did then, far into the interior of the continent; but with the deflected Equatorial Current it would no longer be supplied with water of a tropical temperature, but would have had the normal temperature of the latitude, and even this would have been greatly diminished by the glacial coldness of the waters brought down by the Mississippi and the Ohio.

With the removal of the Gulf Stream the North Polar Current could have had no higher temperature than that which it derived from the Temperate Zone, thus greatly intensifying the cold, so that the moisture which the atmosphere contained would have been condensed out of it in the form of snow in much lower latitudes than at present, probably forming a great ice-barrier across the northern extremity of the North Atlantic. With such an extensive field of ice between the Atlantic and Arctic Oceans it is improbable that sufficient water could remain in the atmosphere to admit, within the area of the latter, sufficient precipitation to form ice-floes as extensive, or as thick, as occur there now.

With the British Isles covered with a great thickness of snow, and with glaciers coming down to the sea, it may be presumed that the southern limits of the ice-drift might have ranged from somewhat south of 50° N. to about 60° N. near the longitude of Iceland; but an extensive frozen area, such as it would have formed, would condense the water contained in the atmosphere, so that, upon the supposition that there exists an open Polar Sea where our Arctic explorers expect to find it, the ice-floe caused by its precipitation could then have hardly extended much farther northward than the latitude of North Cape, the most northern point of Norway, and beyond it there would probably have been an open Polar Ocean.

Prof. Geikie and Mr. James Geikie have shown that in Scotland there are evidences which demonstrate the occurrence of a succession of Glacial Periods, having intervening times characterized by a mild and even genial climate. These intercalated temperate periods have been considered to be indirectly due to the precession of the Equinoxes, which during a period of extreme eccentricity would gradually have caused the supposed ice-cap to shift from one pole to the other. The occurrence of a succession of depressions and upheavals of Central America, causing communications and separations of the two oceans, would certainly cause the same phenomena to take place, and might not only account for these interposed Glacial Periods, but also for the occurrence of shells having a boreal character during intervals in the Tertiary Period. It is a circumstance not unlikely to have happened, but of which we have no absolute proof; nor has any evidence of it been sought for. Temporary upheavals and subsequent depression have been not unfrequent both during the deposit of Palæozoic as well as more recent formations.

Mr. P. P. Carpenter has suggested that the intercommunication between the two oceans may have been correlative with the glacial conditions in European seas; whilst others, and none more clearly than Messrs. Croll and Geikie, have demonstrated how immensely the temperature of the North Atlantic would be diminished by the removal of the Gulf Stream, causing "Scotland to experience a climate as severe as that of Labrador, while the greater part of Norway would be uninhabitable."[1]

It has now, I think, been proved that, with the present contour of the

[1] Mr. James Geikie, "Great Ice Age."

shores of the North Atlantic, the occurrence of extreme cold, dependent on the winters occurring when the earth is at its greatest distance from the Sun, and during great eccentricity of its orbit, is inadequate to cause glacial conditions in the British Isles and Eastern Europe. The same reasoning which has been used to demonstrate it will also apply to their occurrence as a consequence of a *supposed* increase of the obliquity of the Ecliptic.[1] The diversion of the Gulf Stream is upon all hands considered sufficient to produce all those effects which occurred in Britain during the Glacial Period; and there are many evidences which tend to prove that subsidence of the isthmus has taken place, so as to allow of this change in the direction of the Equatorial Current, but, to obtain absolute proof, it is requisite that investigations, with this object in view, be made in Nicaragua and other parts of Central America.

II.—Did the Cold of the Glacial Epoch extend over the Southern Hemisphere?

By Capt. F. W. Hutton, F.G.S.

So many geologists appear to take it for granted that the cold of the Glacial Epoch extended over the whole earth that a few words of caution from the Southern Hemisphere may not perhaps be out of place.

The existence in the Pleistocene Period of a Glacial Epoch in Europe and North America having been firmly established, the former greater extension of glaciers in many other parts of the world is considered to be explained by the Glacial Epoch, and at the same time is taken as a proof of the universal extent of the cold, and therefore of its cosmical origin. But we must remember that out of a number of mountain chains which reach above the level of perpetual snow, those only would not show traces of a former greater extension of their glaciers which now happen to stand at a higher elevation than in past ages; and of the chains that do not now attain to the limit of perpetual snow, but had passed that limit at some previous period in their history, would also show traces of former glaciation. So that a former greater extension of glaciers in a district by no means proves a general reduction of temperature; and I need hardly point out that we have but two means of proving a former reduction of temperature at the sea-level, viz. (1) the migration of a fauna towards the Equator, caused by the gradually increasing cold; and (2) the former extension of glaciers into the sea in places where at present they terminate at a certain height above it; and in the latter case the difference of level must be so great that it could not be accounted for by a former greater snow-fall in the district. Now I believe that no good evidence of either one or other of these has been adduced in any country in the Southern Hemisphere, and until this is done

[1] Climate of the Glacial Period. By Thomas Belt, F.G.S. Quart. Journ. of Science, 1874, page 461. Variations in the Obliquity of the Ecliptic. By Colonel A. W. Drayson, F.R.A.S. Quart. Journ. of Science, 1875, page 279.

we must look with suspicion on all cosmical theories which attempt to explain the cold of the Glacial Epoch.

Mr. Croll's theory has found great favour because it was supposed to rest on astronomical evidence, while in reality the astronomical evidence is, if anything, slightly against it; and the theory is founded on speculations in Meteorology, a science not even so well understood as Geology. The theory of the change in the obliquity of the ecliptic, advocated by Lieut.-Colonel Drayson, Mr. Belt, and others, is simply a supposition which is altogether opposed by astronomy.[1] For if the position of the ecliptic has ever changed as much as has been supposed, it is evident that astronomers must be wrong in attributing the present change in the obliquity to the joint attraction of the planets; and in my opinion it is premature to call in cosmical theories, founded on conjecture, to explain the cold of the Glacial Epoch, until we are compelled to do so by the absolute proof of its universality.[2]

But at present there is no proof of a Glacial Epoch in the Southern Hemisphere, and all the evidence that can be adduced on the subject appears to me to negative such a supposition. There are only three countries where we can expect to obtain proof or disproof of the former existence of a Glacial Epoch in the Southern Hemisphere, viz. South America, New Zealand, Tasmania and Australia; and I have placed the names in the order of their relative importance with regard to this question. I will begin with New Zealand, which is the only one of the three on which I can offer any original observations.

New Zealand extends over 13 degrees of latitude from 34° S. to 47° S. and the difference between the mean annual temperatures of the two extremities is rather more than 10° Fahr. Having resided at Auckland in the north, at Wellington in the centre, and at Dunedin in the south, I can, from my own observations, state that a considerable difference exists in the molluscan faunas of all these three localities. It would, perhaps, be more correct to say that the northern and southern extremities of New Zealand have each their own fauna (which commingle in Cook Straits), with, however, a preponderance of northern forms. This difference in the faunas is greater than would appear by mere lists, for many species which are abundant in the north are extremely rare in the south, and some species that are abundant in the south are very rare in the north. I do not intend here to go into details on this subject; I only wish to point out that New Zealand extends over a sufficient number of degrees of latitude, and has a sufficiently different fauna at its

[1] The theory referred to by Capt. Hutton is indeed opposed to the views of some *astronomers*, but not necessarily therefore to *Astronomy*.—Edit. Geol. Mag.

[2] A more serious difficulty for Geologists has arisen than that of explaining the cold of the Glacial epoch; namely, to explain the warm-temperate and even subtropical heat of the Earlier Tertiary periods in high northern latitudes. Such changes are not "founded on conjecture." See Prof. Nordenskiöld's article in the November Number of the Geol. Mag. p. 525. See also Address to the Geologists' Association, by H. Woodward, F.R.S., Nov. 6th, 1874, Proc. Geol. Assoc. 1875, vol. iv.—Edit. Geol. Mag.

northern and southern extremities to exhibit migration by change of climate; and of course it is at the centre, or Cook Straits, where we could best trace these migrations.

Now it so happens that at Wanganui, in Cook Straits, we have the most extensive Pleistocene shell-bearing bed in New Zealand, and as the fossils are well preserved and easily extracted, it has been pretty thoroughly worked. From this bed 91 species of shells are known, of which 81 are still living in the seas of New Zealand. Of these

Murex octogonus, Quoy.
Trophon Paviæ, Crosse.
Fusus Zealandicus, Quoy.
Neptunæa triton, Lesson.
—— *nodosus*, Quoy.
Cassis pyrum, Lam.
Turritella vittata, Hutt.
Crypta contorta, Quoy.
Monilea egena, Gould.
Pholadidea tridens, Gray.
Zenatia acinaces, Quoy.
Venus Zealandicus, Gray.
Chione Yatei, Gray.
Callista disrupta, Desh.
Mysia Zealandica, Gray.

are not now known to live on the coasts of Otago, although all are, I believe, still found in Cook Straits. On the other hand, *Pecten radiatus*, Hutt., which at present has only been found living in Foveaux Straits, occurs fossil in the Wanganui Pleistocene bed. There is therefore here no evidence of reduction of temperature in the early part of the Pleistocene period.

Below this Pleistocene bed at Wanganui a blue clay is found, from which 98 species of shells have been obtained. Of these, 77 species still inhabit the seas of New Zealand, and consequently I consider this clay to belong to the newer Pliocene Period. Among the recent shells found in it are

Murex Zealandicus, Quoy.
—— *octogonus*, Quoy.
Trophon Paviæ, Crosse.
Fusus pensum, Hutt.
—— *caudatus*, Quoy.
—— *Zealandicus*, Quoy.
—— *mandarinus*, Duclos.
—— *dilatatus*, Quoy.
Euthria littorinoides, Reeve.
Neptunæa triton, Less.
—— *nodosus*, Quoy.
Drillia Novæ-Zealandiæ, Reeve.
—— *Buchanani*, Hutt.
Cassis pyrum, Lam.
Turritella vittata, Hutt.
Crypta costata, Desh.
—— *profunda*, Hutt.
Buccinulus Kirki, Hutt.
—— *alba*, Hutt.
Pholadidea tridens, Gray.
Zenatia acinaces, Quoy.
Venus Zealandica, Gray.
Callista disrupta, Desh.
Dosinia lambata, Gould.
Mysia Zealandica, Gray.

—all of which live north of Cook Straits, but none of them are known from Otago. However, in the same bed *Drillia lævis*, Hutt.,[1] and *Pecten radiatus*, Hutt., also occur, which at present are only known to live in Foveaux Straits. I have also travelled over, and mapped, the whole of the Province of Otago, and have met with no stratified till, nor any marine beds intercalated between glacial or glacier deposits; although since the Pleistocene Period the land has been undergoing elevation. On the whole, therefore, the evidence is decidedly against the idea that a colder climate formerly obtained in New Zealand.[2]

[1] A minute shell dredged in Foveaux Straits, which may have been overlooked in the north.

[2] Dr. Hector, F.R.S., Director of the Geological Survey of New Zealand, was the

Professor M'Coy has also come to the conclusion that there was no Glacial Epoch in Victoria. He says: "All our evidence, in fact, goes to show that there was no Glacial Period in Victoria succeeded by a warmer modern one, but that there has been a regular and gradual falling of the temperature to the present day."[1]

In his "Geological Observations on South America," Mr. Darwin, when mentioning any recent shells found fossil in the Pleistocene beds of Patagonia and Chili, always states that the living forms are found within a few miles of the fossil ones; and never in any instance does he mention them as belonging to species now living further to the south.

I have not seen the late Prof. Agassiz's account of his visit to Patagonia, further than the short notice published in "Nature," but I do not think that he procured any evidence of a northerly migration of the fauna in Pleistocene or Pliocene times, followed by a southerly remigration; nor even of glaciers having formerly entered the sea in more northern latitudes than they do now. However, the evidence, as far as South America is concerned, can be better studied in England than in New Zealand, and the object of this paper is to point out that there is no evidence whatever of a Glacial Epoch having occurred in New Zealand, although, if it had occurred, there is every reason to expect that it would have left sufficiently clear traces behind it.

I will also add that as New Zealand is nearly antipodal to Great Britain, any change of climate in one place, caused by a change in the position of the earth's axis of rotation, would also necessitate a similar change in the other place.

III.—On the Classification and Nomenclature of Rocks.

By S. Allport, F.G.S.

In the September Number of the Geol. Mag. pp. 425, 426, there are some remarks by Mr. G. H. Kinahan on the nomenclature of certain igneous rocks, on which I should like to offer a few observations. The rocks referred to belong to the acidic group, and are mentioned under the various names of granite, nevadite, granitic rhyolite, liparite, trachyte, elvanite, siliceous elvanite, felstone, bottleite, trachalite; the two last being synonymous, for it appears that bottleite is the local name for a vitrioid rock pronounced to be trachalite; but several of the other names are also synonymous or useless, for we are told that nevadite—a proposed new addition to our granitic rocks—is characterized by a more or less crystalline felsitic matrix inclosing crystals of quartz, one or two felspars with mica or amphibole. Now, such a rock may be either a 'granitoid

first, in 1863, to oppose the notion of a *Glacial epoch* in New Zealand as quite irreconcilable with observed facts; and he showed that the former extension of the glaciers is sufficiently accounted for by the gradual reduction of the surface-area exposed above the perpetual snow-line; firstly by its erosion into valleys, ridges, and peaks; and secondly by its gradual subsidence. [See his paper Journ. Roy. Geograph. Soc. 1864, p. 103; and Geol. Mag. 1870, Vol. VII. p. 95.]—Edit. Geol. Mag.

[1] Ann. Nat. Hist. 3rd series, xx. p. 194.

variety of liparite,' a 'granitic rhyolite,' an elvanite, or a siliceous elvanite, for the definition given would be quite as applicable to any one as to the others. Nevadite is then said to represent "the passage rock between trachyte and normal granite; similarly, as a siliceous elvanite among the older rocks, is the passage rock between felstone and normal granite." The author then informs us that he suspects the existence of passage rocks between *augite* and *granite*; and these are subsequently mentioned as "maculated basic rocks which seem to graduate into dolerite and augite." It has, of course, been long known that the extremes of the acidic and basic series overlap, and that some of these intermediate forms exhibit a complete transition from the trachytes to the dolerites; they are, in fact, the trachy-dolerites of Abich, and there are rocks of quite similar composition belonging to the older geological periods; but a rock intermediate between augite and granite must be something new, and petrologists will, no doubt, be glad to learn something more about it.

If to the ten names above mentioned be added andesite, dacite, and domite among the more recent rocks, and felsite, petrosilex, felspar porphyry, quartz porphyry, hornstone porphyry, eurite, pegmatite, granitite, etc., among the older series, the reader will have some faint idea of the amount of confusion introduced into the nomenclature of one group of rocks by the mis-directed ingenuity of those who, like species-makers in other branches of natural science, are never so well pleased as when inventing new names for mere local varieties.

Now it appears to me, that if we wish to introduce something like order and simplicity into our rock-nomenclature, we may as well commence by discarding the old notion of an essential original difference between volcanic rocks of different geological periods; and I imagine there will be found a general disposition among geologists, not only to deprecate the introduction of new names for mere varieties, but also to insist on the necessity of reducing the number of those now in common use. The existence of the two great groups of acidic and basic rocks has long been recognized, not only among the products of recent volcanos, but also in association with strata belonging to the older formations. I have shown elsewhere, that basic rocks of widely separated geological periods are identical in composition and structure, and every additional investigation clearly indicates that the same generalization may be applied to the members of the acidic group. In the older series, for example, there are the felsites or felstones, and the porphyritic felsites or "felspar porphyries," which with the addition of free crystallized quartz, become "quartz porphyries," "elvanites," etc.; and among the Tertiary or recent rocks there is the strictly corresponding series of trachytes, porphyritic trachytes, quartz trachytes or liparites. The mode of occurrence of all these rocks is precisely the same, and the members of the two groups cannot be distinguished from each other, either by mineralogical composition or structure.

It will probably not now be disputed, that there are true granites of all ages, and sooner or later it will be recognized, that the old felstones and porphyries were originally identical with the more recent trachytes; corresponding varieties occur in both series, and microscopic examination clearly shows that the difference observable in some of the older rocks is the result of chemical or other metamorphic action to which they have been exposed.

There is, however, an occasional difference in texture which should not be overlooked. There can be but little doubt that in the intrusive sheets of various old rocks we have before us some of the products of volcanic action which have been formed far below the surface, or, at any rate, beneath great piles of ejected and loosely-aggregated materials, which have been subsequently removed by denudation. Rocks thus formed under pressure might be expected to differ considerably in structure, if not in composition, from those poured out on the surface; and this is frequently, though by no means invariably, the case: for the central parts of many lava flows are as compact, and exhibit precisely the same texture, as the sheets which have been intruded among the surrounding strata. Generally, however, the upper and lower surfaces of true lava-flows are distinctly vesicular or scoriaceous, a character not exhibited by intrusive sheets, but one quite as common in Silurian or Carboniferous lavas as in those of recent formation.

Intimately connected with this subject is the old distinction between the so-called plutonic and volcanic rocks, a distinction which I have long held to be entirely erroneous in the sense in which it is frequently employed, but which is still maintained by authors of the highest repute, more especially among our German friends. As an example, I may adduce the last edition of Naumann's "Lehrbuch der Geognosie" (vol. ii. p. 63), in which it is made the basis of his classification, the plutonic formations being characterized as eruptive rocks not formed by true volcanos. A list of the rocks is then given, and among them are included diorite, diabase, augitporphyr, gabbro, hypersthenite, melaphyr, with their conglomerates and tuffs. But all these rocks are now well known to be true volcanic products; the so-called melaphyres, diabases, etc., of Silurian and Carboniferous ages are frequently found regularly interstratified with beds of ash; the separate flows are scoriaceous and slaggy at top and bottom, and they are evidently as true lavas as any of those ejected by still active volcanos.

It appears, then, that there are two fallacies underlying the present system of classification: 1st, that plutonic rocks have not been formed in connexion with true volcanos; and 2nd, that rocks of different geological ages are characterized by a difference in mineral constitution. In the first place it may be remarked that the doctrine laid down in the former proposition can be nothing more than a mere assumption, which, from the very nature of the case, can seldom or never be capable of demonstration; for if certain masses were originally formed far below the surface, and are now exposed above it, the overlying rocks must have been removed, and with them has disappeared all evidence as to their volcanic or other mode of origin. Fortunately, however, it is not now necessary to have recourse to hypothetical reasoning on the subject, for there is the clearest evidence that the so-called plutonic rocks are in reality the lower portions of true lava-streams which have reached and flowed over the surface. In that most interesting and important contribution to science which Mr. Judd recently laid before the Geological Society (Quart. Journ. vol. xxx.), he has clearly shown that, among the Tertiary volcanic rocks of the Hebrides, deeply formed granite passes by insensible gradations into felsites which have reached the surface; and that the coarsely crystalline gabbros of the central parts of the volcanos also pass gradually into dolerites and basalts, which formed lava-streams of enormous extent.

Admitting, then, the inaccuracy of the prevailing views on the two points just mentioned, the question of classification and nomenclature becomes considerably narrowed and simplified. For if it be the fact that there have been true volcanos from the earliest period in which there is evidence of life, or of the earth being in a habitable condition, and also that the products of volcanic action have been, with perhaps a few exceptions, the same from the earliest to the present period, it becomes evident that they should be regarded as forming one natural group, and classified in accordance with such definite and ascertained characters as they may be found to possess. Some of these have been long recognized. The separation, for example, of the entire series of volcanic rocks into the two classes of *basic* and *acidic*, is simply the expression of a well-ascertained fact, which may be verified in every quarter of the globe; and the subdivision of the latter into rocks possessing a *granitic*, *felsitic*, and *vitreous* texture, with their respective porphyritic varieties, although based on more special characters, is nevertheless of wide application.

So far, there are but few difficulties to contend with; but in the adoption of specific names, there is abundant opportunity for those who like to exercise their ingenuity in the discovery of a new species in every variety of rock that happens to fall into their hands. They havea lready made the list too long, and it might be at once advantageously curtailed by the rejection of several synonymous or otherwise bad terms. Among these I should include: felstone, felspar porphyry, quartz-porphyry, and elvanite, which would be better named: felsite, porphyritic felsite, and porphyritic quartz-felsite, though the latter is rather long. Elvanite is, however, a bad name for it, as the rock is not, as was supposed, really characteristic of the Cornish elvans. An examination of a large series of these rocks clearly shows that they are simply dykes, very many of which consist of typical granite, while others are quartz-felsites which are frequently porphyritic in texture.

In whatever sense the local Cornish term elvan may have been originally used, it has now no very definite application, for in addition to the granitic and felsitic elvans, there are the 'blue' and 'grey' elvans of the miners, some of which are altered gabbros and dolerites, or even hard altered slates.

In conclusion, it would, I think, be premature at present to suggest any great changes either in classification or nomenclature; but from the progress already made in the examination of rocks, with improved methods of investigation, it appears probable that a few more years will suffice for the acquisition of a more complete knowledge of the numerous varieties of volcanic rocks, of their constituent minerals, and of the various modes in which they may be associated.

IV.—Wind Denudation.—Eolites.

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

I AM not aware that any geological notice has been taken of the effect of the wind on a flat sandy shore, further than the simple removal of the sand therefrom, and its collection on the sea-margin in the shape of sand dunes.

At the present moment a walk on the shore at Blundellsands has vividly impressed me with the efficacy of this agent—wind—as a denuder.

Though I have frequently observed the phenomenon I am about to describe, after continued gales from the North-West, I never saw it displayed in so uniform a manner as now. There has been a continuance of wind from the North-West for a lengthened period, and the shore between high-water of neaps and springs is covered with little ridges of sand lying with their axes parallel and in the same direction as the wind. The uniformity and parallelism of direction is most remarkable, and would, supposing they were to be preserved by being filled up with fine silt in places, and ages hence were converted into rock, show to a future geologist unerringly the direction of the wind at the time they were formed. The largest of these little ridges are about $2\frac{1}{2}$in. long, and their height about $\frac{3}{8}$in., and as I counted of all sizes 12 in a space of 6 inches, it would be safe to average them at $\frac{1}{2}$ an inch apart. A closer examination shows that the windward or "crag" end, which is the highest, is usually capped with the fragment of a shell, and also that this end is often an overhanging point or veritable "crag." Where best developed, they look like a shower of darts, shot into the ground at the same angle. So much for the facts. Now, what do they tell us? In the first place, it is quite evident that they are formed by the excavation of the surrounding sand, and indicate the depth to which the sand has been removed; the shell-capped points are the original surface of the shore, and the shells have acted in preserving an approximately horizontal pillar of earth behind them, like the stones capping the "earth pillars" shown in Lyell's "Principles," have caused the vertical earth pillars by protecting the ground underneath from rain denudation. Here the parallel ceases, for the moisture in one case causes the denudation, whilst the drying up of the moisture by the wind does so in the other. Where these minute ridges are best developed, the shore is always moist, and the wind effects the removal of the sand by drying the surface grains and blowing them away, any little protection in the shape of a larger object, such as a shell fragment protecting the sand in the rear, and so forming a "crag and tail."

As the whole of this denudation, which otherwise would go unnoticed and unmeasured, must have taken place since last spring-tide, we see what an enormous mass of sand has been moved since that time. The greater part of this no doubt does not get beyond the reach of the tide, and is blown on to the higher parts of the shore, to be perhaps again washed into the sea. Moisture is essential to the production of these little ridges—shall I call them "Eolites"?—and it is instructive to observe on the extreme upper and *dry* part of the shore that the effect of the wind is to cause ripple marks at *right angles* to its direction, and almost undistinguishable from true water ripple marks. I estimate that the denudation has been fully $\frac{1}{4}$ of an inch or 33 cubic yards per acre in about a week, or say 2000 tons along our two miles of shore. It would be interesting to know if any geologist has ever unearthed a fossil answering this description.

[See a letter from Mr. Joseph Duff in Geol. Mag. 1865, Vol. II. p. 136, on Carboniferous Sandstone with surface-markings (Plate IV.), also one from the late Alexander Bryson, Esq., F.R.S.E., on Surface-markings on Sandstone (with a Woodcut), *op. cit.* p. 189. The wave-like and rippled arrangement of the surface of the sand in the Sahara caused by the prevalent N.E. winds has frequently been alluded to by travellers. See Élisée Reclus "The Earth," Section I. English edition, edited by H. Woodward, F.R.S., 1871, p. 93.—Edit. Geol. Mag.]

V.—Notes on Some Sarsden Stones.

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

I. *Concretionary with Calcareous Cement.*—Last autumn the Rev. John Adams, of Stockcross, kindly took me to see the interesting specimen of Sarsden Stone *in situ* at Langley Park, north of Newbury, Berks, which he described in the "Transact. Newbury District Field Club," vol. i. 1871, p. 107, and in the Geol. Mag. Vol. X. p. 200; and which has also been described by Mr. W. Whitaker in the "Memoirs Geol. Survey," vol. iv. p. 193. This concretionary Sarsden Stone, belonging to the "Woolwich and Reading" series, consists of quartz grains with a *Calcareous* cement. This is an unusual circumstance for "Sarsden Stone"; and points to the former presence of Shells, perhaps, or of calciferous waters, in that portion of the Lower Eocene series. A somewhat similar quartzose sandstone, but with smaller and more uniform globules held together by carbonate of lime, occurs in the Hastings Sandstone at the East Cliff, Hastings; and another in the Triassic series of Brunswick. In the concretionary sandstone from Langley Park, the lines of stratification are clearly apparent here and there on the weathered sides of the globular, botryoidal, and mammillary masses. These do not show a distinct radiate structure, such as is more or less visible in those from Hastings and Brunswick; and these, again, are of course less radiate within than the far more purely calcareous concretions of the Magnesian Limestone of Durham.

II. *Root-marked.*—In a piece of the usual hard siliceous quartzose

Sarsden Stone, of the "Bagshot" series, from the gravel near Frimley, Surrey, I find remarkably clear indications of vertical rootlets,—that is, numerous, irregularly tubular cavities, sometimes furcate, more or less occupied by ochreous matter, which breaks with a kind of thready structure, and leaves linear impressions, like those of woody fibres. Seven of these root-marks, passing through a slab more than an inch thick, are exposed in a fracture six inches long; and the upper and lower surfaces of the slab are irregularly pitted by having been weathered and worn at and around the exposed ends of the tubes. These are more open and trumpet-shaped on one surface than on the other, towards which latter is directed the occasional branching of the rootlets.

Similar vertical root-marks are found, as is well known, in other sandstones; notably in those of the Estuarine series in the Lower Oolite of Yorkshire; and in those of the coal-bearing sandstone of Höganäs and Helsingborg in South Sweden. Such rootlets, in a carbonized state, are seen in the clay-seams underlying the lignites of the "Bracklesham" Series[1] in Alum Bay, Isle of Wight. Vertical root-marks, but usually very long and thin, are also seen in the Hastings Sandstone. (Geologist, vol. v. 1862, p. 136, fig. 9.)

The definite disclosure of the vertical tubular Root-marks on the Sarsden Stone above mentioned tends to explain the cause of some of the varied pittings seen on many weathered blocks of this stone; and I find that, on fracture, some at least of such weathered pittings are succeeded downwards in the stone by obscure, discoloured, vertical lines, which are probably due to the imperfect mineralization of the contents of original root-holes.

It would be interesting to know with what marine or estuarine plants, *Zostera*, *Potamogeton*, etc., such vertical root-marks in these old sandstones and clays originated.

VI.—A Chapter in the History of Meteorites.

By Walter Flight, D.Sc., F.G.S.,
Of the Department of Mineralogy, British Museum.

(*Continued from page* 560.)

1866, June 9th.—Knyahinya, near Nagy-Berezna, Unghvár, Hungary.[2]

Shortly after this remarkable shower of meteorites had taken place two very full reports on the occurrence were drawn up by von Haidinger. It is computed that over a very limited area more than a thousand stones, weighing in all from 8 to 10 cwt., must have fallen. The largest found is now preserved in the Vienna Collec-

[1] The root-marked Sarsden Stone came probably from the Upper Bagshot Sand: a rather higher stage than that of the white clays here alluded to.

[2] A. Kenngott. *Sitzber. Ak. Wiss. Wien*, 1869, lix. 873. *Phil. Mag.*, 1869, xxxvii. 424.—J. V. Schiaparelli. Entwurf einer astronomischen Theorie der Sternschnuppen. 1871. Stettin: Nahmer. Page 267.—E. H. von Baumhauer. *Archives Néerlandaises*, 1872, vii. 146.—See also W. von Haidinger. *Sitzber. Ak. Wiss. Wien*, liv. 200 and 513.—G. Rose. *Monatsber. Ak. Wiss. Berlin*, lxvii. 203.

tion; it weighs 293·3 kilog. (5 cwt. 3 qrs. 3 lbs.), and measures 2 ft. 4 in. long and 18 in. broad, and penetrated the ground to a depth of 11 ft. For drawings of this enormous block, the largest mass of meteoric rock preserved in any collection, and coloured representations of the meteor which was observed at the time of its descent, the reader is referred to von Haidinger's two memoirs.

Kenngott has published the results of a microscopic investigation of thin sections of a fragment of this meteorite, illustrated with eight drawings indicating peculiarities of structure. To the naked eye the section appears to be finely granular and of a grey tint, and even with a very moderate power is seen to present spherular structure, recalling, if relative size be left out of consideration, that of the globular diorite of Corsica. The opaque ingredients are nickel-iron, troilite, and a black substance; in addition to these are two crystalline mineral species, the one colourless and transparent and somewhat fissured, the other grey and translucent and presenting an appearance of lamellar structure; both appear in angular and rounded granules, and both are bi-refractive; they are differently affected by hydrochloric acid, and from other differences in their crystalline characters it may be inferred that the grey silicate is enstatite, the colourless silicate is peridot. It is hardly possible to give the reader in a small compass an idea of Kenngott's detailed description of the various granules; the grey mineral he observed to constitute several of the round or rounded granules, and in most of the specimens there was clear evidence that the two silicates had crystallized simultaneously; in one instance an alternation of the two minerals in one and the same granule, as it occurs in globular diorite, is remarked, the interior consisting of the grey mineral, finely striated and surrounded with black opaque substance, around which again is a granular aggregation of the transparent fissured silicate, locally interspersed with particles of the black opaque substance and of nickel-iron.

Fragments heated before the blowpipe become covered with a black enamel, while the grey powder of the meteorite, when moistened with distilled water, reacts distinctly, sometimes intensely, on turmeric paper. The specific gravity of this stone is 3·515.

It was not until a lapse of six years from the date of this very abundant aerolitic fall that a specimen was submitted to careful chemical analysis. Von Baumhauer, by whom it was undertaken, finds the Knyahinya meteorite to have the following composition:—

Nickel-iron	5·0
Troilite	2·2
Chromite...	0·8
Olivine	39·9
Insoluble silicate	52·1
	100·0

The nickel-iron contains:

Iron = 79·94; Nickel = 20·06. Total = 100·00

The silicates, separated by the action of acid and sodium carbonate, consist of:

	SiO_2	Al_2O_3	FeO[1]	MgO	CaO	K_2O	Na_2O	
A. *Soluble*......	37·16	0·27	26·54	30·18	2·43	2·14	1·28	= 100·00
B. *Insoluble*...	56·35	5·93	11·22	19·58	3·97	1·11	1·84	= 100·00

The soluble portion is olivine, having the composition $(Mg\,\frac{2}{3}\,Fe\,\frac{1}{3})_2$ SiO_4: it is identical with that which, according to Damours's analysis, constitutes the meteorite of Chassigny (1815, October 3rd), and occurs as one of the ingredients of so many meteorites. In the insoluble portion the ratio of the oxygen of the silicic acid to that of the total bases is 2 : 1. Von Baumhauer points to a resemblance between these ingredients and those forming the insoluble portion of the meteorites of Chantonnay, Seres, and Blansko, analysed by Berzelius, as well as that of the Utrecht stone, which he himself examined. He considered it (the insoluble part) to be in that case a mixture of albite and augite; Rammelsberg, on the other hand, held that it consisted either of labradorite and hornblende, or oligoclase and augite; a considerable proportion may be bronzite.

On the last page of Boguslawski's translation of Schiaparelli's *Note e Riflessioni sulla teoria astronomica delle Stelle cadenti* is an interesting mathematical demonstration that the meteorites of Knyahinya and Pultusk (1868, January 30th) cannot have come to us from the same part of space.

1866, December 6th.—Cangas de Onis, Asturias, Spain.[2]

In Meunier's interesting paper a drawing is given of this curious stone, which he selects as one exhibiting peculiarities of brecciated structure and the relation of meteoric rocks to each other as regards stratification. The stone contains abundance of fragments of a white ingredient enclosed in a darker material; the white portions he finds to be identical with the rock forming the meteorite of Montréjeau (1858, December 9th), while the duller substance, cementing them together, is the same as that constituting the stone which fell at Adare, in Ireland (1813, September 10th). He terms these two rock varieties: montrésite and limerickite. Meunier gives November 30th as the date of the fall of this meteorite.

According to a very incomplete notice of Luanco's paper, which has reached me, one of these stones weighs 11 kilog., and the chief constituents appear to be silicic acid, magnesia, and lime, with 38·8 per cent. of iron and 1 per cent. of nickel. As, however, the proportion of iron present as nickel-iron and as protoxide is not stated, no calculation with a view to determining its proximate composition can be attempted.

Found 1866.—Sierra de Deesa, near Santiago, Chili.[3]

Meunier has studied the two fragments of this iron preserved in the Paris Collection, and finds it to possess characters of which a

[1] With traces of manganese protoxide.

[2] S. Meunier. Les Pierres qui tombent du Ciel. *La Nature*, 1873, i. 403.—J. R. Luanco. *Ann. Soc. Españ. Hist. Nat.*, iii. part i.

[3] S. Meunier. *Cosmos*, 1869, vii. (v. ?), 188, 552, 579 and 612. *Sitzber. Ak.*

superficial view of the exterior gives no indication. It appears to resemble an ordinary meteoric iron, but when sawn through it is found to enclose siliceous fragments, black in colour, markedly angular, and varying in size from a few millimetres to two centimetres; in these in some cases lie embedded grains of nickel-iron and spherular particles of troilite. Troilite, as well as occasionally little pieces of schreibersite, are also observed in the metallic portion. According to Domeyko this iron consists of:

Nickel-iron	95·92
Schreibersite...	1·42
Silicate	2·40
	99·74

Meunier found in one specimen 1·7 per cent. of silicate. The siliceous portion is distributed sparsely and so irregularly throughout the mass that it is impossible to judge with any accuracy of the composition of the meteorite *en bloc.*

A portion of the siliceous ingredient from which a great part of the metal had been detached had the composition:

Nickel-iron	12·62
Troilite (?)	5·01
Chromite, schreibersite and graphite...	traces
Soluble silicate	40·82
Insoluble silicate	41·55
	100·00

Domeyko found the nickel-iron and schreibersite to consist of:

Iron = 90·88; Nickel = 9·12 = 100·00
Iron = 65·00; Nickel = 26·30; Phosphorus = 8·70 = 100·00

The density of the iron = 7·51; it does not show Widmannstättian figures when etched, although small plates enclosed in the alloy develope a pattern. The numbers yielded by the analysis of the phosphide correspond with the formula $Fe_4\,Ni_2\,P$.

Meunier adopted a novel means for analysing the nickel-iron: he reduced it to fine particles with a hard file, and fused them with caustic potash in a silver crucible; in this way the sulphur and phosphorus of the troilite and schreibersite are rendered soluble and removed with water. To ensure a perfectly pure condition of the metal it is treated with fuming nitric acid, and is then dried and heated cautiously in a current of air; when the requisite temperature is reached the particles change colour, those acquiring a blue tint are kamacite, $Fe_{14}\,Ni$, and those a yellow are tänite, $Fe_6\,Ni$. In the case of the Deesa iron nearly all the particles turned blue, a yellow grain being observed here and there. Meunier finds the composition of the nickel-iron, iron sulphide and schreibersite to be:

I. Iron = 91·4; Nickel = 7·2 = 98·6.
II. Iron and Nickel = 58; Sulphur (calculated) = 42 = 100.
III. Iron = 60·00; Nickel = 26·75; Phosphorus = 10·29 = 97·04.

Wiss. Wien, 1870, lxi. 26. *La Nature*, 1873, i. 405.—W. von Haidinger. *Sitzber. Ak. Wiss. Wien*, 1870, lxi. 29.—See also G. A. Daubrée. *Compt. rend.*, 1868, lxvi. 571.

I. agrees with Domeyko's analysis as regards the iron; II., a very imperfect analysis, accords rather with the formula of pyrrhotite than troilite; and III. differs considerably from the numbers corresponding with the accepted formula of schreibersite.

The composition of the portions separated with acid is:

	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	
A. *Soluble* ...	44·13	trace	—	13·52	42·35	—	trace	= 100·00
B. *Insoluble* ...	49·98	5·46	0·98	16·79	23·31	3·48	trace	= 100·00

In the soluble part the oxygen ratios are approximately those of olivine, in the insoluble part those of pyroxene. While the presence of olivine could not be detected in the mass by any crystalline features, in the insoluble part three minerals were recognised. The most apparent has a blackish-brown colour, lamellated structure and a specific gravity = 3·35. The composition was found to be:

Silicic acid	51·61
Alumina	7·36
Iron protoxide	24·54
Magnesia	16·05
Lime	3·68
	103·24

The second is white and granular, and possesses the following constitution:

Silicic acid	55·76
Magnesia	41·85
Lime	3·89
	101·50

and closely accords in composition with one of the three (III.) varieties of enstatite met with in the Busti meteorite (see page 411). A third mineral, to which Meunier has given the name of victorite, resembles hypersthene, occurs in colourless and transparent crystals in a geode of 5 mm. diameter; they form six-sided prisms terminated with four-sided pyramids. Through some fragments very small opaque black grains are disseminated, with here and there the cavities and rounded enclosures first observed by Sorby. The prisms are grouped in a remarkable way. This mineral, which is present in so small a quantity that none of it could be sacrificed for analysis, has been declared by Des Cloiseaux from the following measurements to be enstatite:

g^1 m	=	134° 3′ to 134° 20′.
g^1 h^1	=	90° 40′.
g^1m on h^1	=	46°.
m h^1	=	137° 20.
mm′ on h^1	=	93° 0′ to 93° 40′.
h^1m (left)	=	136° 25′; and 135° 40′ (?).
g^1 m′	=	134° 0′; and 134° 40′.
mm′ on g^1	=	88° 40′.

Meunier finds this meteorite to be identical, as regards composition, with that which fell at Tadjera, near Sétif, Algiers (1867, June 9th), in which also he recognised the presence of this variety of enstatite. (See page 595.)

1867, January 19th.—Saonlod, 3 Miles N. of Khettree, Shekawattie, Rajputana, India. [Lat. 28° 9′ 45″ N.; Long. 75° 51′ 20′ E.][1]

A shower of stones, numbering about forty, fell near the village of Saonlod on the above day, at 9 A.M. The morning was bright and clear, and no clouds were to be seen, when a loud report, resembling that of a cannon, was heard over an area many miles in length and breadth, and was succeeded by two still louder, and followed in turn by "a regular roll, resembling musketry heard at a short distance." The terrified inhabitants of the village where the stones fell, seeing in them the instruments of vengeance of an offended deity, set about gathering all they could find, and, having pounded them to powder, scattered them to the winds. A gentleman connected with the Topographical Survey, who happened at the time to be a few miles distant from Saonlod, states that he sent all the sowars attached to his camp to scour the country, with the intention of procuring as many of the stones as possible. He adds: "I was very nearly too late, as, between them all, they only managed to get the piece I sent, ... and that under promise of a large reward." According to the description, given by the more respectable class of natives, some of the meteorites were of the size of a 24-pounder shot, and had a blackish appearance on the outside; they fell with such velocity that they sank two or three feet into the ground in a sandy soil.

The stone has a nearly black crust, cellular on the surface and corrugated somewhat longitudinally, and is about one-third of a millimetre in thickness. The interior has a light bluish-grey colour in some parts, and a much darker grey in others; the two portions lie side by side like two strata in some places, while in others a nodule of the one is seen to be enclosed in the other. The freshly fractured surface is studded with metallic particles of nickel-iron, and exhibits translucent granules of a greenish yellow, which are probably olivine. Siliceous spherules, as well as cavities once occupied by them, are also observed, and when the mineral is finely powdered and examined under water with a lens, the lighter portion of the stone exhibits a considerable quantity of nearly white crystalline particles, mixed with small angular fragments of black, brownish, greenish yellow, and opaque minerals, as well as rounded particles of nickel-iron; the dark-grey portion has very much the same appearance.

The meteorite is not very hard; the specific gravity of some small pieces of the light-coloured portion was 3·743, of the dark-coloured variety 3·612, while analysis showed it to consist of:

Nickel-iron	18·55
Troilite and schreibersite	5·22
Soluble silicate	35·18
Insoluble silicate	42·36
	101·31

The metallic portion contains:

Iron = 91·54; Nickel = 6·79; Cobalt = 1·15; Chromium = 0·52. Total = 100·00.

[1] D. Waldie. *Jour. Asiat. Soc. Bengal*, 1869, xxxviii. 252.—*Records Geol. Survey India*, 1870, ii. 101; 1870, iii. 10.

The sulphide and phosphide are assumed by the author to consist of:

Iron = 51·54; Sulphur = 33·71; and Iron = 12·46; Phosphorus = 2·29. Total = 100·00.

He regards the iron sulphide "as Fe_7S_8, troilite," a view which is hardly tenable in face of the fact that Dr. L. Smith and Rammelsberg, who have analysed the nodules of the mineral, which occur in the meteorites of Knoxville, Seeläsgen and Sevier Co., Tennessee, have shown it to be a monosulphide. Again, no schreibersite has yet been met with which does not contain a very considerable percentage of nickel, the whole of which metal the author takes to be present in the metallic ingredient.

The siliceous portions separated by treatment with acid and sodium carbonate have the following composition:

	SiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	X[1]	
A. *Soluble* ...	30·50	1·17	—	21·35	39·11	1·93	0·26	5·68	= 100·00
B. *Insoluble* ...	57·67	3·22	0·95	8·62	23·70	4·00	1·84[2]	—	= 100·00

While the soluble portion appears to be chiefly olivine, that which resisted the action of acid may be taken to be bronzite, together with a few per cent. of a felspathic ingredient, possibly labradorite.

The Khettree meteorite, in point of composition, resembles that which fell at Klein-Wenden, near Nordhausen, Prussia (1843, September 16th).

1867, June 9th.—Tadjera, near Sétif, Province of Constatine, Algiers.[3]

A meteor was seen to traverse the sky over this district, and two stones, weighing 5·76 and 1·70 kilog., fell near Sétif. The siliceous portion of the stone has a black colour which distinguishes it from most meteorites, and it is further remarkable for the absence of the usual fused crust. It has a specific gravity of 3·595 and the following composition:

Nickel-iron	8·32
Troilite	8·04
Chromite	0·20
Soluble silicate	54·64
Insoluble silicate	28·80
	100·00

The nickel-iron consists of:

Iron = 91·6; Nickel = 8·4. Total = 100·0.

and the siliceous portions separated with acid and sodium carbonate:

	SiO_2	Al_2O_3	Cr_2O_3	FeO	MgO	CaO	Na_2O	
A. *Soluble* ...	45·24	0·81	—	11·17	42·78	—	trace	= 100·00
B. *Insoluble* ...	50·21	4·15	0·41	27·99	8·03	9·21	trace	= 100·00

In the soluble portion the silicic acid is in excess of that required to

[1] Constituents removed with sodium carbonate, but undetermined.
[2] With trace of potash.
[3] S. Meunier. Thèse présentée à la Faculté des Sciences de Paris, 1869. *Recherches sur la Composition et la Structure des Météorites*, 13. *Compt. rend.*, 1871, lxxii. 339. *Cosmos*, March 28th, 1866, 7.—See also G. A. Daubrée. *Compt. rend.*, 1868, lxvi. 513. *Cosmos*, March 21st, 1868, 25.

form olivine, in the insoluble part of that required to form bronzite; in the latter case a portion of the acid is probably present as a constituent of a felspar.

1868, February 29th.—Villanova di Casale Monferrato, Province of Alessandria, and Motta dei Conti, Province of Novara, Italy.[1]

The village of Villanova lies on the left bank of the Po, 5 kilometres N.E. of Casale Monferrato and 2 kilometres from the village Motta dei Conti. Between 10·30 and 10·45 A.M. (local mean time) on the 29th February, the sky being calm but cloudy with cirri, cirro-cumuli and cumuli, a loud detonation was heard which was noticed in many villages and towns of this part of Piedmont. In Casale the noise resembled the discharge of artillery or the explosion of a mine; while an observer stationed near the confluence of the Sesia and the Po states that he heard a crackling noise like the discharge of musketry afar off. Near Casteggio, in the district of Voghera, Alessandria, a mass was observed to traverse the heavens with great rapidity, leaving a black track resembling smoke; and two explosions were heard followed by a prolonged noise. A medical man who was near Santo Stefano d'Aveto, in the district of Chiavari, Genoa, saw a globe of fire of considerable size cross the sky from N.W. to S.E. at the same time.

One meteorite fell about 600 metres S.E. of Villanova; it crashed through the branches of a tree and entered the ground a few paces distant from a terrified peasant, who, believing it to be a bomb, fell on his face. The villagers were filled with alarm at the occurrence, and some oxen yoked to a plough near Roggia Marcora stood still with fear. The stone penetrated the clayey soil to a depth of 0·4 metre, and on the following day was exhumed by a boy, while the courageous owner of the field sheltered himself securely hard by and watched the operation.[2]

The Villanova meteorite has somewhat the form of a cube and measures 0·08 metre along the side; it weighs 1·92 kilog. and has a specific gravity = 3·29. It is covered with a thin hard brown crust; the interior has a mottled grey colour and a fractured appearance, and is very friable. The matrix is stated to enclose grains of an ochrey-yellow hue, others much larger and of a brown colour (chromite), as well as lustrous metallic particles, the remainder consisting of various stony ingredients, some consisting of microscopic crystals.

[1] A. Goiran, A Bertolio, A. Zannetti, and L. Musso. Sopra gli Aeroliti caduti il giorno 29 febbraio 1868 nel territorio di Villanova e Motta dei Conti, Piemonte, circondario di Casale. Con Introduzione del padre Denza. 1868, Torino. See also *Bull. meteor. dell' Osserv. del R. Coll. Carlo Alberti in Montcalieri*, March to June, 1868. – F. Denza. *Compt. rend.*, 1868, lxvii. 322.—G. Jervis. I Tesori Sotterranei dell' Italia. Parte Prima. 1873, Torino: Loescher. Page 153.

[2] The trajectory of this stone could be approximately determined since three points in a vertical plane were determined: 1) the point where it grazed the top of a tree, 2) the broken end of the bough of a walnut tree severed by the meteorite, and 3) the point where it entered the ground. Other peasants, who were employed lopping trees near the high road which leads from Casale to Vercelli, at a point about 1200 metres from Villanova, observed a rain of black grains; one man was struck on the hat with a piece of considerable size.

According to Bertolio this meteorite consists of:

Iron	20·700
Nickel oxide	5·371
Manganese and copper	traces
Sulphur	0·503
Phosphoric acid	0·597
Chlorine	0·105
Silicic acid	39·661
Alumina	0·415
Chromium sesquioxide	0·036
Iron protoxide	12·234
Magnesia	14·776
Lime	0·878
Potash and soda	4·151
	99·427

A second stone, weighing 6·311 kilog., fell in a cornfield near the farm Roletta at a spot 2350 metres distant from the first. In form it somewhat resembles a truncated pyramid, and measures 0·223 metre in its greatest length and 0·14 metre in its greatest breadth; it also is covered with a thin crust, evidently the result of fusion. It is preserved in the Natural History Museum of the University of Turin. The authors of the paper above alluded to consider the two Villanova stones to be distinct meteorites, and not fragments resulting from the explosion of a single mass during its passage through our atmosphere; their opinion is shared by Denza.

At the same time a meteorite fell at Motta dei Conti, the village already referred to. It struck the pavement in front of a tavern with great violence, driving the slab 0·5 cm. into the ground, and the shattered fragments rebounded over the roof of a small dwelling 7 metres high; their united weight is estimated to have been from 300 to 500 grammes. According to the list of the specimens, quoted by Jervis as preserved in collections, their total weight does not exceed 30 grammes. Bertolio, who submitted a small portion of the Motta dei Conti stone to examination, declares it to differ both in physical characters and chemical composition from the Villanova meteorites; the disparity, however, is not difficult to account for. He finds this stone to be more magnetic and dense (specific gravity = 3·76) than the others, and to contain no lime and scarcely a trace of alumina. A fragment of a meteorite, containing nearly one quarter of its weight of nickel-iron would, during the rough treatment to which this stone was subjected, lose much of the interstitial rocky matter and acquire a greater density in consequence, while the proportion of the two oxides in the Villanova is in any case so small that the indications they may give in a qualitative examination of so small a quantity of material could hardly warrant our drawing a conclusion as to whether or no it had a common origin with, or similar constitution to, the Villanova stones. All the remaining ingredients of the latter are likewise found in the Motta dei Conti meteorite. It is stated that a fourth stone fell further north in the water of the Roggia Marcova, in the parish of Caresana.

Daubrée points out that the above meteorites do not essentially differ from others which have fallen in Piedmont during the first half of the present century at Cereseto (1840, July 17th), and at Guiliana Vecchio (1860, February 2nd); and finds them very similar in characters to the meteorites which fell at Oviédo, Spain (1856, August 5th), and in the Commune des Ormes, Yonne, France (1857, October 1st).

1868, March 20th.—Daniel's Kuil, N.N.E. of Griqua Town, Griqua Territory, South Africa.[1]

This meteorite fell near a Griqua at Daniel's Kuil, who picked it up while warm; he gave it to Captain Nicolas Waterboer, the Griqua Chief, from whom Gregory obtained it. It was broken into two parts when it reached his hands, and has since unfortunately been divided into several more; it weighed 2lb. 5oz. The crust has a dull black colour; immediately below it for a thickness of about $\frac{1}{8}$th of an inch the stone has a browner colour than the interior, the result of oxidation. The rock has a dark grey colour and a fine granular texture, and encloses a very considerable amount of nickel-iron in a finely divided condition, as well as particles of troilite and schreibersite. The rounded grains so commonly present in meteoric rock are not seen.

This meteorite has been examined by Church, who finds it to possess the specific gravity 3·657 to 3·678, and the following composition:

Nickel-iron	29·72
Troilite	6·02
Schreibersite	1·59
Silica and Silicates	61·53
Carbon, Oxygen, other constituents, and loss	1·14
	100·00

The nickel-iron contains:

Iron = 94·72; Nickel = 5·18. Total = 100·00.

The per-centage of troilite is based on a sulphur determination made in a separate portion; the schreibersite "was approximately estimated by calculating its amount as being ten times that of the unoxidised phosphorus in the stone"—a novel method which can hardly be considered a satisfactory one. The rocky portion of the stone, constituting nearly two-thirds of the mass, does not appear to have been submitted to detailed analysis, although we are told that the silicates consist chiefly of olivine and labradorite, "the former species constituting by far the larger portion of the powder unaffected by dilute acids." Olivine, as is well known, is the meteoric silicate *par excellence* which is broken up by such reagents, being easily acted upon even by dilute hydrochloric acid. Church does not state whether he succeeded in detecting the presence of alumina in this meteorite, although he numbers labradorite among its constituent minerals; while the occurrence of silica, as such, in a meteorite is so very rare, having as yet been isolated and submitted to analysis in one instance

[1] A. H. Church. *Jour. Chem. Soc.*, 1869 [2], vii. 22. *Jour. Prakt. Chem.*, 1869, cvi. 379.—See also J. R. Gregory, Geol. Mag. Vol. V. p. 531.

only (see p. 551), that an investigation of this question is desirable. The author further states that in a second portion of the same sample he found the silicates to amount to 61·10 per cent., in another fragment to 48·99 per cent.; while in yet another portion the nickel-iron, judging from the per-centage of nickel it contained, constituted 39·20 per cent. of the stone.

Found April, 1868.—Losttown (2½ miles S.W. of), Cherokee Co., Georgia.[1]

According to Shepard's first notice, this block of iron has the form of a human foot and weighs 6lbs. 10oz. "Widmannstättian figures are visible directly in one portion of the surface;" those presented by treatment with acid are stated to be very beautiful and to most nearly resemble the figures of the Seneca Lake iron. The nickel, which in the first notice is stated to be abundantly present, although the development of the figures would not lead one to expect the per-centage to be large, proved on analysis to be considerably below the average, as the following composition shows:

Iron = 95·759; Nickel = 3·660; Insoluble portion = 0·580. Total = 99·999.

The insoluble part is stated to consist of schreibersite and rhabdite; traces of cobalt, chromium magnesium, and tin (?) were detected. The specific gravity of the iron is 7·52.

1868, July 11th.—Ornans, Doubs, France.[2]

This meteorite is described as differing in appearance from any of the stones which have fallen in Europe during recent times. It has a dull grey colour, and is so friable that it can be crumbled between the fingers. It is very porous; a fragment immersed in water absorbed about $\frac{1}{10}$th of its weight of water in two hours. Particles of iron can only be detected here and there with a lens, and the stone is feebly magnetic. The specific gravity of the rock is 3·599, and it consists of:

Nickel-iron	1·85
Magnetic pyrites	6·81
Chromite	0·40
Olivine	75·10
Insoluble silicate	15·26
	99·42

The portions of silicate separated by the treatment with acid were:

	SiO_2	Al_2O_3	FeO	NiO	MgO	CaO	K_2O and Na_2O	
A. *Soluble*......	33·37	3·93	30·76	3·83	26·37	1·74	—	= 100·00
B. *Insoluble* ...	40·43	8·98	10·55	—	30·15	6·29	3·60	= 100·00

Pisani, it will be seen, is of opinion that a portion of the nickel is present in the form of oxide in the silicate which gelatinises with acid. He determined the amount of iron present as metal by measuring the volume of hydrogen which it evolved

[1] C. U. Shepard. *Amer. Jour. Sc.*, 1869, xlvii. 234.—See also *Amer. Jour. Sc.*, 1868, xlvi. 257.

[2] F. Pisani. *Compt. rend.*, 1868, lxvii. 663.—G. Tschermak. *Sitzber. Ak. Wiss. Wien*, 1870, lxii. 855.

during its solution in acid. In calculating the results of his analysis he considers the sulphur to be combined with a portion of this iron in the form of magnetic pyrites, and the remainder of that metal to be alloyed with some of the nickel, the excess of the nickel above that required to form the normal alloy being present as oxide. As, however, it has not been shown to be a component of the silicate, and recent researches (see page 315) have failed to prove that it forms a constituent of meteoric olivine, it may be present as alloy. If we exclude the oxygen of this nickel oxide, the ratio of the oxygen of the silicic acid to that of the total bases of that portion is 13·35 : 13·43, from which it appears that the chief constituent of the Ornans meteorite is an olivine having the formula $2\ (\frac{3}{5}\ Mg\ \frac{2}{5}\ Fe)\ SiO_4$.

Tschermak finds that the dull grey colour of this stone is due, at least in part, to the presence of carbonaceous matter. (Compare with Goalpara meteorite, page 605.)

1868, September 7th.—Sauguis-St.-Étienne, Canton de Tardets, Arrondissement Mauléon, Basses-Pyrénées.[1]

At 2·30 A.M. a meteor emitting a pale green light traversed the sky over Mauléon, and broke up leaving a faint whitish cloud which lasted for some time. Its disappearance was succeeded by a noise as of thunder, followed by three or four loud detonations, which were heard over an area 80 kilometres wide. The inhabitants of Sauguis-St.-Étienne heard, in addition to these noises, a sound like that produced by quenching hot iron in water, and a dull thud caused by the meteorite striking the ground. It fell about 30 metres from the church in the bed of a small stream, and was so completely shattered that the largest fragments did not measure more than 5 cm. in length; their total weight is about 2 kilog. The fall was witnessed by two men, who, returning home late, had continued in conversation at the door of one of their dwellings. Frightened by the hissing noise, they fell on the ground, and saw the stone strike the earth about 20 metres from them.

The Sauguis meteorite consists chiefly of rocky matter, the metallic grains being small and sparsely distributed; troilite is noticed in nodules, some of which are 10 mm. across. The crust is dull black and possesses the unusual thickness of 1 mm.; the fine black veins observed to traverse certain meteoric rocks are abundantly present in this stone. A microscopic section was found to act strongly on polarised light, and to have the appearance of a breccia of very small transparent and colourless particles.

Daubrée finds the rock composing this meteorite to be identical in all respects with that forming the stones which fell at Villanova di Casale in Piedmont (1868, February 29th) [see page 596]; a practised eye examining specimens of these two falls would fail to distinguish one from the other.

[1] G. A. Daubrée. *Compt. rend.* 1868, lxvii. 873.—S. Meunier. Thèse presentée à la Faculté des Sciences de Paris, 1869. *Recherches sur la Composition et la Structure des Météorites*, 16.

According to Meunier this stone has a specific gravity = 3·369,[1] and consists of:

Nickel-iron	8·050
Troilite	3·044
Soluble silicate	65·909
Insoluble silicate	23·571
	100·574

The nickel-iron contains:

Iron = 93·88; Nickel 6·12. Total = 100·00.

and the portions of the silicate separated by treatment with acid and sodium carbonate:

	SiO_2	Al_2O_3 & Fe_2O_3	Cr_2O_3	FeO	MgO	CaO	K_2O	Na_2O	
A. *Soluble*......	45·66	—	—	3·05	50·68	—	0·61	trace	= 100·00
B. *Insoluble* ...	61·96	2·56	0·05	8·49	24·62	2·12	0·20	—	= 100·00

In both portions the silicic acid is considerably in excess of that required to form a silicate of the form of olivine in A, and of a bronzite in B. The amount of iron protoxide in the portion which gelatinised with acid is unusually small.

Meunier refers to this meteorite in his description of the stone which fell at St. Denis-Westrem, near Ghent (1855, June 7th). (See p. 500.)

1868, October 17th.—Lodran, Mooltan, India.[2]

This meteorite fell at 2 P.M. on the above day, the descent being accompanied with a loud explosion, which appeared to come from the east. The chondritic structure noticed in many meteorites was not observed in this stone, but enclosed within its black crust was found a magma of siliceous particles of so coarse-grained a character that the individual granules occasionally measured 2 mm. in diameter. The constituent minerals were carefully isolated before analysis, which showed the stone to consist of:

Nickel-iron	32·5
Magnetic pyrites	7·4
Olivine	28·9
Bronzite, with some chromite and anorthite .	31·2
	100·0

The alloy, an important ingredient, which developes figures resembling those of the Senegal iron, forms a mesh-work enclosing the silicates, the crystals of olivine not unfrequently leaving a complete impression of their faces in it; it has the following composition:

Iron = 85·44; Nickel = 12·79; Magnesia = 0·25; Residue = 0·81. Total = 99·29.

Associated with the substance just mentioned and occasionally entangled in the silicates were fragments of magnetic pyrites: they possess no crystalline structure and dissolve in acid with deposition of sulphur. The olivine is of a bluish grey to Prussian blue colour,

[1] In his paper on the Belgian meteorite, a specific gravity = 3·43 is given.

[2] G. Tschermak. *Sitzber. Ak. Wiss. Wien*, 1870, lxi. 465. *Pogg. Ann.*, cxl. 321. —*Records of the Geological Survey of India*, vol. ii. part 1, page 20.

and occurs in unusually well-developed crystals, which have been found by von Lang to agree in all respects with the olivine from basalt; the following measurements were made:

				Calculated.
100, 110	=	65° 2′	......	65° 2′
110, $1\bar{1}0$	=	49 49	......	49 57
100, 210	=	About 46 30	......	47 2
100, 310	=	35 30	......	35 36
100, 210	=	41 0	......	40 27

The fissures of many of the crystals are filled with a black mineral of a dendritic form; this is assumed to be chromite and is believed to be a secondary formation. This silicate has the specific gravity 3·307 and the following composition:

Silicic acid	40·14
Chromium oxide	0·60
Iron protoxide	13·55
Magnesia	46·01
	100·30

These numbers differ only to a slight extent from those of an olivine in which the two compounds $Mg_2 SiO_4$ and $Fe_2 SiO_4$ are in the ratio of 82 : 18.

The bronzite occurs in grains and imperfect crystals, on any of which faces of more than one zone are rarely recognisable. On one crystal von Lang determined the following angles:

				Calculated.
100, 320	=	About 34° 50′	......	34° 30′
100, 110	=	45 56	......	45 52
100, 230	=	57 15	......	57 6
100, 130	=	About 71 56	......	72 5

while a second gave the following numbers:

				Calculated.
110, 010	=	44° 6′	......	44° 8′
010, 110	=	About 44 0	......	44 8

The calculated angles are based on observations made on the bronzite of the Breitenbach siderolite (see page 549). The plane of the optic axes is parallel to the zone [110, 010] and the mean line perpendicular to 010 has a negative optical character. The specific gravity of this mineral is 3·313 and the composition:

Silicic acid	55·35
Alumina	0·60
Iron protoxide	12·13
Magnesia	32·85
Lime	0·58
	101·51

which corresponds, in point of constitution, with a bronzite in which the isomorphous compounds $Mg SiO_3$ and $Fe SiO_3$ are present in the ratio 78 : 22.

When a microscopic section of this mineral is examined it is found to enclose three substances: 1) colourless chondra of a doubly refracting mineral, which the crossed Nicols show to be twinned, and which is probably a felspar; 2) small round black particles, usually lying in groups, and believed to be chromite; and 3) fine hair-like bodies, disposed parallel to the cleavage-planes; their nature could not be determined. The plate accompanying Tschermak's paper furnishes drawings of all these substances.

In addition to the octahedral faces (111) von Lang observed on the chromite crystals faces of the rhombic dodecahedron (110) and the leucitoid (311), and made the following measurements:

				Calculated.
111, $\bar{1}$11	=	70° 31′	... ...	70° 32′
011, 131	=	31 25	... ...	31 29
131, 113	=	50 25	... ...	58 29

1868, November 27th.—Danville, Alabama. [Lat. 34° 30′ N.; Long. 87° 0′ W.][1]

During the (American) war, writes Dr. Laurence Smith, artillery had often been heard in the valley of the Tennessee, and various speculations were indulged in as to the meaning of a loud report, like that of a cannon, which occurred at about 5 P.M. on the day above mentioned, and appeared to come from a direction northward of Danville. On the following day a man brought to that town a piece of rock which, he said, fell near him and some labourers who were picking cotton at a place 3 miles W. of Danville. It entered the soil to a depth of $1\frac{1}{2}$ to 2 feet, and when exhumed was found to weigh about $4\frac{1}{2}$ lbs. Several stones fell in the neighbourhood; one near some negroes at work in a cotton-field, two others whizzed right and left past two men who were ploughing a field about $1\frac{3}{4}$ miles N.W. of Danville.

The meteorite which reached Dr. Smith's hands, the first of those mentioned, has the usual black crust, which is rough and dull, and appears in some parts to have been whipped round, as it were, and rolled over the border on to the unfused surface as the stone traversed the atmosphere.

A fresh surface has a dark grey colour, and is less chondritic than is the case with many meteorites, and there are veins or patches of a slate-coloured mineral running across it. Iron sulphide and nickel-iron are diffused through the rock, the latter more especially in the slate-coloured areas; and there are occasional white patches of what is probably enstatite.

The meteorite has a specific gravity of 3·398, and contains 3·092 per cent. of nickel-iron consisting of:

Iron = 89·513; Nickel = 9·050; Cobalt = 0·521; Phosphorus = 0·019; Sulphur = 0·105; Copper, trace. Total = 99·208.

and the iron sulphide contains:

Iron = 61·11; Sulphur = 39·56. Total = 100·67.

If the excess over 100 be deducted from the iron, the chief constituent, these numbers correspond very closely with the per-centages of magnetic pyrites (pyrrhotite), not with iron protosulphide, as stated in this paper; troilite, the presence or absence of which

[1] J. L. Smith. *Amer. Jour. Sc.*, 1870, xlix. 90.

was not established, is of course the monosulphide. The rocky portion of the Danville meteorite consists of:

Soluble silicate	60·88
Insoluble silicate	39·12
	100·00

and has the following composition:

	SiO_2	Al_2O_3	Cr_2O_3	FeO	MnO	MgO	CaO	K_2O	Na_2O	S	P	
A. *Soluble*..	45·90	1·73	trace	23·64	trace	26·52	2·31	0·64	0·51	1·01	trace	=102·26
B. *Insoluble*	50·08	4·11	—	19·85	—	20·14	3·90	—	—	—	—	= 98·08

In the soluble portion the excess over 100 is due to some of the iron regarded as oxide being present in combination with sulphur; this portion is chiefly olivine, that insoluble in acid is bronzite with a little augite or felspar.

The author finds this meteorite to be similar in every respect to the stone which fell in Harrison Co., Indiana (1859, March 28th), which in many catalogues is incorrectly referred to Harrison Co., Kentucky (1859, March 26th).

1868, December 5th.—Frankfort, Franklin Co., Alabama.[1]

The fall of this meteorite, which occurred at 3 P.M. on the above day, was attended by three loud reports, immediately succeeded by a series of sounds like that of a great fire blazing and crackling. The descent took place four miles S. of Frankfort, and was witnessed by Mr. J. W. Hooper, who saw the stone strike some willow saplings about 70 or 80 yards from him; on going to the spot, he found it nearly buried in the ground and still warm. The noise of the explosion was heard 20 or 25 miles E. and W. and 15 or 20 N. of Frankfort. Mr. Hooper made notes of the occurrence, and sent the stone for analytical examination. "He refused with scorn money offers, which must have been tempting to a person of limited income, preferring the advancement of science to dollars and cents."

The meteorite, which is almost entirely covered with a very lustrous black crust, so thin in some parts that fragments of olivine can be distinguished through it, weighs 615 grammes, and has a specific gravity of 3·31. A fractured surface presents a pseudo-porphyritic structure, having a grey ground on which black, green, white and dark grey spots are seen: the black fragments are very lustrous and slightly magnetic (chromite); and the yellowish-green mineral, passing into yellow and shading into dark grey, appears to be olivine; while the greyer variety cannot, according to Brush, be distinguished from the "piddingtonite" of the Shalka stone, now shown to be no true mineral species (see page 405). Some brilliant points possessing metallic lustre were found to be troilite; and one or two delicate black veins were also observed.

The nickel-iron constitutes only a few hundredths of one per cent., the chromite 0·62 per cent., and the troilite 0·63 per cent. of the

[1] G. J. Brush. *Amer. Jour. Sc.*, 1869, xlviii. 240.

mass; and of the latter about 26 per cent. is soluble in acid. An analysis of a portion of the stone gave the following results:

		Oxygen.	
Silicic acid	51·33	26·37	
Alumina	8 05	3·75	
Chromium oxide	0·42		
Iron protoxide	13·70	3·04	12·28
Magnesia	17·59	7·04	
Lime	7·03	2·06	
Potash	0·22	0·03	
Soda	0·45	0·11	
Sulphur	0·23		
	99·02		

As the greater portion of the lime and but little of the magnesia and iron protoxide were found in the portion soluble in acid, it appears probable that this meteorite will be found after the more detailed investigation, which Brush contemplates undertaking, to consist to a great extent of anorthite, olivine and bronzite. He is of opinion that by sacrificing more material it will be possible to mechanically separate the constituent minerals under a lens. In general physical characters it closely resembles the meteorite of Petersburg, Lincoln Co., Tennessee (1855, August 5th).[1]

Found 1868.—Goalpara, Assam, India. [Lat. 26° 10′ N.; Long. 90° 40′ E.][2]

This meteorite, the date of the fall of which is not known, was first described by von Haidinger, who directed attention to the peculiarities of its form and surface as indicating with great clearness the orientation of the stone in respect to the path of flight through the atmosphere; he remarked among its mineralogical characters differences from those observed in all other meteorites, and described it as an olivinous rock, of coarse grain, and of a very dark grey hue. Von Haidinger's preliminary notice is illustrated with two beautiful plates showing the remarkable form of the stone.

Tschermak, who has made a very complete investigation of this meteorite, describes the exterior as having a deep greyish-brown colour; the fused crust is extremely thin and hard, and is readily removed in flakes. The interior has a porphyritic structure; the deep grey matrix enclosing light-coloured yellow grains, which have a nearly uniform breadth of 1 mm. These included particles are found on closer inspection to be of two kinds; the one exhibiting a very distinct cleavage, the other none. The first mineral is rhombic, has cleavage-planes forming an angle of 92°, is unacted upon by acid, and is identified with enstatite. The second species is also infusible, gelatinises with acid, and is found to be olivine.

The very finely granular matrix, when viewed under a high power, is seen to consist partly of small transparent particles which

[1] J. L. Smith. *Amer. Jour. Sc.* 1861, xxi. 264.

[2] W. von Haidinger. *Sitzber. Ak. Wiss. Wien*, 1869, lix. 224 and 665.—G. Tschermak. *Sitzber. Ak. Wiss. Wien*, 1870, lxii. 855. *Jahrbuch für Mineralogie*, 1871, 412.

appear to be olivine, partly of opaque material in which reflected light reveals the presence of three substances: a sponge-like mass, the thin cell-walls of which are minute crystals, some cubic in form, and readily identified by their lustre with nickel-iron; a smoke-brown pulverulent lustreless substance, of which more will be said below; and diminutive yellow metallic granules, which are probably magnetic pyrites. The relative position which these ingredients occupy in the mass of the rock is clearly shown in the beautiful microscopic drawings accompanying Tschermak's paper.

When a fragment of the meteorite is treated with acid the nickel-iron, magnetic pyrites, and olivine decompose, and at the outset a little sulphuretted hydrogen is disengaged; soon an odour is remarked like that attending the solution in acid of iron containing combined carbon. After prolonged action the residue is still grey; on diluting the solution with water, however, this grey matter rises to the surface, or if it should happen to adhere to the silica can, through its lower specific gravity, be separated by elutriation. When heated on platinum foil the grey substance disappears; it possesses in every respect the properties of soot. This carbonaceous matter is the dark-coloured lustreless ingredient of the matrix already mentioned.

The Goalpara stone has a specific gravity = 3·444 and consists of:

Nickel-iron	8·49
Hydrocarbon	0·85
Olivine	61·72
Enstatite...	30·01
Magnetic pyrites	trace
	101·07

If the total amount of silica, determined by analysis, be apportioned to the bases in the soluble and insoluble portion, it is found, in the first instance, that the olivine contains in 100 parts:

Silicic acid	37·81
Iron protoxide	18·99
Magnesia	43·20
	100·00

These numbers show the mineral to be made up of the silicates $Mg_2\ SiO_4$ and $Fe_2\ SiO_4$ in the ratio of 3 : 1. The insoluble portion has the following composition:

Silicic acid	56·72
Iron protoxide	5·33
Magnesia	35·95
Lime	2·00
	100·00

The enstatite is remarkable for the small per-centage of iron oxide present; it may be a mixture of a pure magnesian enstatite with a little of the ferriferous variety, bronzite, and is possibly associated with a small amount of augite.

This meteorite, it is seen, consists for the most part of olivine and enstatite, an association of minerals previously noticed by Tschermak in the stone which fell at Lodran (see page 601). The presence of carbonaceous matter forming 0·85 per cent. of the stone, and consisting of 0·72 carbon and 0·13 hydrogen, constitutes by far the most striking feature of this meteorite. While the carbonaceous meteorites which fell at Kaba, Alais, etc., have a very loose texture, the Goalpara stone exhibits great toughness.

A list of meteorites containing carbon has been given on page 19; to that must be added the names of those which fell at Renazzo (1824, January 15th), Mezö-Madaraz (1852, Sept. 4th), Ornans (1868, July 11th), and Zsadány (1875, March 31st).

[1868].—Auburn, Macon Co., Alabama.[1]

In October, 1868, Prof. Darby, of the East Alabama College, drew up a report on a mass of meteoric iron which had been ploughed up "many years since," in the Daniel plantation near Auburn. It was a nearly round mass, weighing about 8 lbs.; it is traversed with such deep cracks and open veins that it would not be difficult to break it in pieces; on one side a "globule" of troilite, half an inch in diameter, was noticed. When etched the iron exhibits a meshwork of exceedingly thin lines, the areas within the lines being lustrous when viewed in a certain direction; the former appearance is ascribed to thin plates of schreibersite, the latter to sections of needles of rhabdite.

The metal has a specific gravity of 7·05, and the composition:

Iron = 94·580; Nickel = 3·015; Phosphorus = 0·129; Insoluble portion = 0·523. Total = 98·247.

Besides the above ingredients the presence of undetermined quantities of chromium, calcium, magnesium, and silicium (?) was recognised. Shepard states that "neither cobalt, tin, nor copper was detected in this iron." Commenting on this statement and the observations of other investigators, where the fact of the presence of cobalt in meteoric iron has not been actually recorded, Dr. L. Smith says:[2] "I cannot but suggest the importance of making a most critical examination of these irons before pronouncing this fact; for in every analysis that I have made of meteoric irons (over one hundred different specimens) with this in view, cobalt has been invariably found, along with a minute quantity of copper."

[N.D.]—Collina di Brianza, near Villa, Milan.[3]

It is stated by Chladni[4] that this mass of metal was found about 40 to 50 years earlier (which would be about 1769-79) while digging the foundations of a house, and that it was placed in the Convent of S. Alessandro. Guidotti, Klaproth, and Gehlen, to whom fragments were sent for analysis, found neither nickel, chromium, phosphorus, nor carbon in it, and considered it to be very pure iron; so malleable was it, in fact, that Chladni had a tuning-fork forged from it. Specimens

[1] C. U. Shepard. *Amer. Jour. Sc.*, 1869, xlvii. 230.—L. Smith. *Amer. Jour. Sc.*, 1870, xlix. 331.
[2] J. L. Smith. Mineralogy and Chemistry, 352.
[3] K. Haushofer. *Jour. Prakt. Chem.*, 1869, cvii. 328.
[4] E. F. F. Chladni. Ueber Feuer-Meteore. Vienna: 1819. Page 349.

of this mass, which weighed originally from 200 to 300 lbs., are to be met with in most collections; its cosmical origin, however, has been regarded as doubtful, especially since Stromeyer reported that he had discovered the presence of carbon in the metal. It has recently been submitted by Haushofer to a fresh examination with the aid of the more delicate analytical methods of the present day, and he finds that the mass is unquestionably meteoric. When etched it gives very distinct Widmannstättian figures. One part of the metal he found to contain 95·2 per cent. of iron, while the composition of another fragment was:

Iron = 91·1; Nickel = 7·7; Cobalt = 0·2; Phosphorus = 0·3; Carbon, trace. Total = 99·3.

He states the specific gravity of the iron to be 7·596, a number very slightly in excess of that given by Chladni. Haushofer finds, as Chladni long since remarked, that the malleable character of the metal varies considerably in different parts of the mass.

With this I conclude the Second Part of the task which I have set myself, that of preparing a critical digest of the results, published during the last seven years, which deal with questions relating to our knowledge of meteorites. In Part II. the readers of this Magazine have in a manner a supplement to Part I., concluded on page 264, and are placed *en rapport* with all that has appeared during those years on the subject of meteorites which have fallen from the earliest times down to the present moment. The remaining matter now in course of preparation, which treats of questions of great importance, although less directly appealing to the readers of the Geological Magazine, will, together with considerable additions to what has already appeared, be incorporated in a little work now passing through the press. I cannot take my leave of the readers of the Geological Magazine without begging my friend and colleague, the Editor, to permit me in these columns to express my very hearty thanks for the generous manner in which, throughout the entire year, he has so liberally granted me space for this "Chapter in the History of Meteorites." W. F.

NOTICES OF MEMOIRS.

On a Mass of Travertine or Calcareous Tuff called the Glen Rock, near Ballycastle, Co. Mayo, Ireland. By Wm. A. Traill, M.A.I. (Master in Engineering), F.R.G.S.I., H.M. Geological Survey of Ireland.[1]

THE author, after briefly describing the district, which consisted of Carboniferous sandstones, shales, and limestones, inclined at low angles E. N. E., referred to the occurrence of stalactitic formations and deposits of carbonate of lime in various places; but especially drew attention to the Glen Rock, distant about two miles from Ballycastle, on the eastern flanks of the valley of the Ballinglen

[1] Read before the British Association, Bristol, 1875, in Section C. Geology.

River, and which forms such a remarkable feature in the district. This rock was a mass of Travertine or Calcareous Tuff, approximately of the following dimensions: in length, N. and S. 310 ft.; E. and W. 285 ft.; and in thickness varying from 6 ft. to about 80 ft., and estimated as containing over 2,100,000 cubic feet.

This tuff varies from a soft, open, porous nature to a hard, ringing travertine. It is in part stalactitic, mammillated, or reniform, and often efflorescent, but mostly an intricate network of the casts or incrusted forms of various vegetations, brambles, grasses, mosses, ferns, ivy, etc., which, on being coated with the deposit of carbonate of lime, and the vegetable matters decomposing, have left their impressions behind. In addition to these are also included the bones of some small animals and birds and the shells of land snails, etc., instances occurring of their being thus entombed while still alive.

The origin or source of this large mass, in the author's opinion, was due solely to a large spring or Holy Well situated a little above, on the slope of the hill, from which there issues a copious and constant supply of water. This probably passing for a considerable distance through the limestone rocks, and becoming thus highly impregnated with lime, and prevented from flowing in a regular channel, overspread the rank vegetation, which engendered a more rapid evaporation and consequent deposition of the carbonate of lime, the marly soil encouraging the more rapid growth of the mosses, ferns, weeds, etc., each in succession falling a prey to the covering of lime as it was deposited upon them, and thus more rapidly building up this isolated mass of calcareous tuff.

At present the action does not seem to be going on as actively as at former times, the stream being more confined to a regular channel, and flowing round the side of the mass; but even still the ivy roots and stems are inclosed in stony cases, the living plant growing out therefrom. Large quantities are annually carried away for spreading over the cultivated lands and for forming ditches.

Although many streams in a limestone country have a tendency to deposit calcareous matter, in few localities in the North of Ireland does there exist such a remarkable and isolated mass of Tuff. The age of this rock must be considered of very late origin geologically, long after the present configuration of the country had been formed, and though probably accumulating somewhat even to the present time, it has not increased in thickness for the last 300 years, as foundations of that age exist on its highest part; it seems rather to be now breaking up under its own superincumbent weight. In the year 1831, a large mass becoming detached fell and completely crushed a cottage which was built adjacent to it, killing four people within it at the time.

In addition to the geological interest, there was an historical and local interest connected with it, and also many legendary tales.

In one portion of the rock, in a cave partly natural, but enlarged to a circular form of about 22 feet in diameter, for upwards of 20 years a school was held, with an attendance of 60 children. This school was supported by the inhabitants of the Glen, but was discontinued in the year 1815, when free schools were established in the district. Christopher Purcell was the last teacher. The roof of the cave has since subsided, and thus it is reduced to its present small dimensions. Tradition states that in 1570 a holy friar with a small community established themselves in a building which they erected on the rock, and of which the foundations are still discernible. At this time the holy well was established and dedicated to the superior of the community as patron saint, under the Irish name of Niéve Eiäne (as pronounced).

The waters of this well are believed to have healing properties, and for some cases water so highly impregnated with lime would be very beneficial. Over the well was a small structure, inside which over the outlet for the water was a carved head of the patron saint; this, however, has been lost, and a rude stone and timber erection is all that now exists.

REVIEWS.

I.—Relics of the Cave-Dwellers of Aquitania.

(PLATE XV.)

MORE than fifty years have passed away since Dr. Buckland,[1] one of the most able and distinguished of our early geologists, commenced the exploration and record of the organic remains found in and beneath the breccias and stalagmites of ossiferous caverns.

But although the Dean was well aware of the occurrence of stone implements of undoubted human manufacture together with human bones in several of these deposits, he was led to conclude that they were not coëval with the Mammoth and other extinct and foreign animals contained in the same cave-earths.

Yet even at that early period, other able and competent observers were at work in the same field of inquiry, who did not share the conclusions of Buckland.

Earliest of these was Dr. Fleming[2] (afterwards Professor of Natural Philosophy in New College, Edinburgh); and the Rev. J. McEnery[3] (a highly intelligent Roman Catholic priest at Torquay); subsequently Dr. Schmerling[4] of Liège; and later (in 1841), M. Boucher de Perthes,[5] of Abbeville, and Dr. Rigolott,[6] at Amiens, carried on their own separate lines of research, which, however, did not result in attracting public attention until after 1858, when the exploration of the Brixham cave stimulated scientific men to take

[1] "Account of an Assemblage of Animals discovered in a Cave at Kirkdale, Yorkshire," 1821, Phil. Trans. vol. cxii. p. 171; and "*Reliquiæ Diluvianæ*," 1826, 4to. Lond.

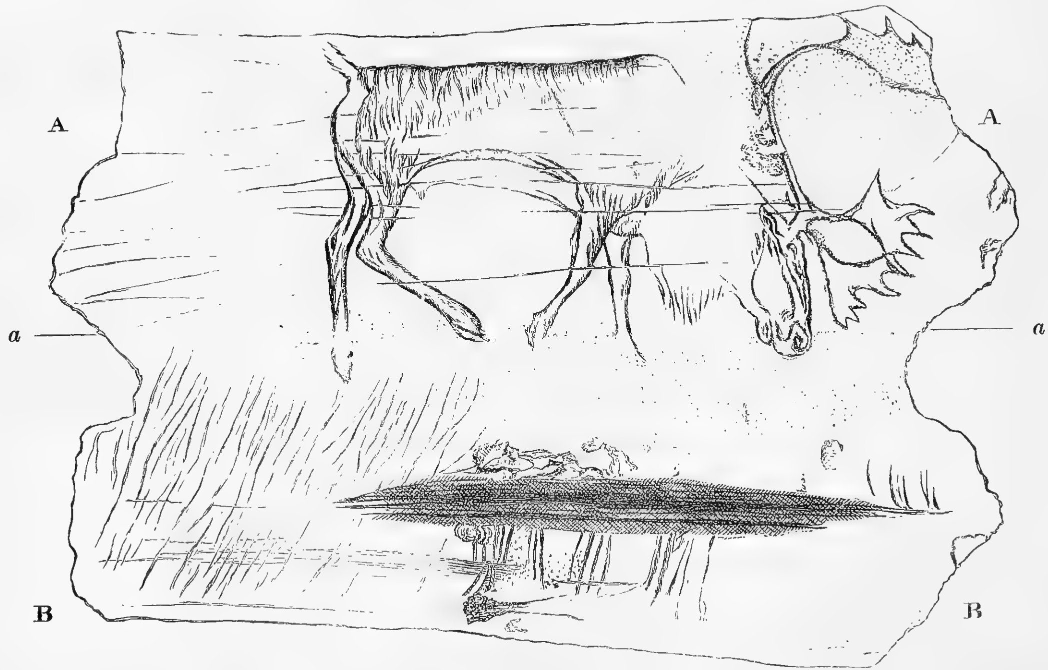
[2] Edinb. Phil. Journ. vol. xiv. p. 205.

[3] McEnery's MS., written in 1824, was not published until 1859, by Mr. Vivian, and more fully by Mr. Pengelly, "Literature of Kent's Cavern," Devonshire Association, 1868–9.

[4] Recherches sur les Ossemens Foss. dans les Cavernes de la Prov. de Liège, 4to. Atlas and folio, 1833–34.

[5] "Antiquités Celtiques," 1847, vol. i.

[6] Comptes Rendus, 1847, p. 649; 1864, p. 230.



Incised Engraving on Reindeer Antler, from the Kesslerloch Cave, near Thaïngen, Canton Schaffhausen.

up and carefully work out this latest of geological periods which stretches to the border-line of Archæology.

When once these researches became known to the world by the writings of Lyell, Prestwich, Falconer, Lubbock, Pengelly, Evans, Lartet and Christy, Boyd-Dawkins and Sanford, Dupont, and many others, it seemed as if the scientific men of every nation had only been waiting some signal to announce their varied discoveries in this field of Prehistoric Archæology.

Thus we simultaneously heard of the discovery of ancient settlements built upon piles in the Swiss Lakes; of Crannoges in the Irish Bogs; of Peat-mosses with abundant relics in Bronze and Stone in Denmark; of shell-mounds and refuse-heaps; of River-valley gravels with flint implements; of ossiferous caverns and rock-shelters in many countries, but notably in England, France and Belgium.

Upon none of these investigations has a larger share of careful and laborious research been bestowed than that which the authors of the *Reliquiæ Aquitanicæ*[1] have devoted to the task of exploring the Caves of the Vézère; but of its two authors, Henry Christy did not live to see the issue of the first part,[2] whilst M. Edouard Lartet[3] died 28th January, 1871, after the completion of the tenth Part.

The task of carrying out the intentions of Mr. Henry Christy as regards the publication of the results of his explorations, and those of his colleague M. Edouard Lartet, has been ably and generously fulfilled by Mr. Christy's brothers; the direction of the work having been entrusted to the care of M. Penguilly l'Haridon, Mr. John Evans, F.R.S., Pres. Geol. Soc. Lond., Mr. A. W. Franks, F.R.S., Dir. S.A., Mr. W. Tipping, F.S.A., and Professor T. Rupert Jones, F.R.S., F.G.S., the last-named gentleman having throughout fulfilled the duties of Editor.

How well that task has been fulfilled, and how carefully and diligently, and lovingly too, each contributor has added of his store, and how all this has been built in and cemented together by the able Editor, Prof. Rupert Jones, let the 530 pages of text (with their accompanying 87 plates and 135 engravings and woodcuts) which complete the work, testify.

Monuments have been erected in all times, of wood, of clay, of stone, of ivory, iron, silver, and gold, but we doubt whether any monument was ever before reared *in paper* to two fellow-workers

[1] *Reliquiæ Aquitanicæ;* being Contributions to the Archæology and Palæontology of Périgord and the Adjoining Provinces of Southern France, by Edouard Lartet and Henry Christy. Edited by Thomas Rupert Jones, F.R.S., F.G S., etc., Professor of Geology, Royal Military and Staff Colleges, Sandhurst. Complete in Seventeen Parts, comprising pp. 530, 4to. Illustrated by 87 plates, 3 maps, and 132 woodcuts. London: 1865–75. H. Baillière, Publisher.

The "*Reliquiæ Aquitanicæ*" has been already noticed in the GEOLOGICAL MAGAZINE for 1866, pp. 76 and 462; 1867, p. 321; 1868, p. 282; 1869, pp. 24, 277, 463; 1870, p. 174; 1873, p. 96.

[2] See Obituary Notice in GEOL. MAG. 1865, Vol. II. p. 286. Mr. Henry Christy died 4th May, 1865.

[3] See Obituary Notice by Pres. Geol. Soc. in Quart. Journ. Geol. Soc., 1872, vol. xxviii. Ann. Address, p. xlv.

in science; yet this volume will probably outlast many of the more ponderous and barbaric structures of the past, and prove a source of knowledge to all who consult its pages.

The Caves and Rock-shelters containing the Aquitanian relics treated of in this work are excavated in cliffs of Cretaceous Limestone along the lower portion of the valley of the Vézère; indeed for nearly thirty miles they form both on the Vézère and its many tributaries those nearly precipitous escarpments which have been in all ages excavated by natural agencies and the hand of man into galleries, recesses, and caverns. These ossiferous caves (whether or not enlarged artificially) have been hollowed out originally by atmospheric agency, the softer bands of limestone having been more readily acted upon by frost and other agencies than the harder beds.

The uppermost of these limestones is characterized by the presence of Rudistes (*Sphærulites*, *Radiolites*, *Hippurites*). The second zone is a Polyzoan Limestone with shells, Echinoderms, and the claws of a Crustacean (*Callianassa*) like that of the Maestricht beds.

The flint occurs as a chert band often containing *Polyzoa*, *Orbitoides*, and even fish-teeth (*Otodus*).

The Caves described are those of Les Eyzies, La Madelaine, Gorge d'Enfer, Cro-Magnon, Le Moustier, besides numerous rock-shelters at Laugerie Haute, and Laugerie Basse, etc.

Although coming within the age of simply-worked stone, without the accompaniment of domestic animals, these caves are by no means on a uniform level as regards the products of human industry.

In only three stations (namely, Les Eyzies, Laugerie Basse, and La Madelaine) have figures of animals engraved or sculptured on stone, on bone, or on reindeer-horn, been met with. At Laugerie Haute lance-heads of flint were found in abundance, whilst arrow-heads or harpoon-heads of reindeer-horn were almost entirely absent, although plentiful at Laugerie Basse and at La Madelaine.

The Cave of Moustier has yielded even more rude and primitive flint-weapons than any, but not a single worked bone or engraved or sculptured figure of any animal. Nevertheless the fauna of the several stations appears to be almost the same.

If we eliminate from the following list the names of certain animals (which in these caves are represented by single fragments of bone or a tooth) such as the Mammoth, the Cave-lion, the Hyæna, and the great Cave-bear, we have seven stations, of perhaps various ages, but all in the Reindeer and Wild-horse Period. These animals, as in the Cave of Bruniquel, on the Aveyron, were evidently the principal objects of the chase, and their remains make up by far the larger bulk of the osseous fragments left in the cave-dwellings.

It is reasonable to assume that the Reindeer went North in summer, and at that season probably herds of Wild-horses took their place, retiring further South than the Reindeer in winter.

The Musk-ox (*Ovibos moschatus*) was probably also a winter visitant; at any rate two portraits have been found of it, carved on bone harpoons (one from Bruniquel, and one from Kesslerloch, near Thäingen, Canton Schaffhausen, in Switzerland); and its bones have also been found in two caves of the Vézère.

The following is a list of the various animals whose remains have been met with in the seven stations explored by Messrs. Lartet and Christy:—

	Le Moustier.	La Madelaine.	Laugerie Haute.	Laugerie Basse.	Gorge d'Enfer.	Cro-Magnon.	Les Eyzies.
Mus musculus, Owen							x
Arvicola, sp.							x
Spermophilus, sp.						x	
——— *erythrogenoides*, Falc.							x
Lepus timidus, Linn.	x	x	x	x		x	x
—— *cuniculus*, Linn.		x				x	
Elephas primigenius, Blum.	x	x	x	x		x	x
Equus caballus, Linn.	x	x	x	x		x	x
Sus scrofa, Linn.		x				x	
Bison priscus, Bojanus,		x				x	x
Bos, sp.	x	x	x	x	x		
Ovibos moschatus, Pallas,		x			x		
Capra ibex, Linn.		x	x	x	x	x	x
Antilope rupicapra,		x		x			x
——— *saïga*, Pallas,				x			x
Cervus elaphus, Linn.	x	x	x	x		x	x
——— *tarandus*, Linn.	x	x	x	x	x	x	x
——— *megaceros*, Owen,			x				
Felis spelæa, Goldf.					x	x	x
Hyæna spelæa, Goldf.	x						
Canis lupus, Linn.		x	x	x	x	x	x
—— *vulpes*, Briss.		x	x	x	x	x	x
Gulo luscus, Linn. (An engraving on bone.)							
Ursus spelæus, Blum.				x	x	x	
Number of Human remains discovered		1		4		5	

No labour or expense has been spared in bringing together in aid of the elucidation of the Prehistoric Archæology of Aquitania, not only all points relating to the manners, customs and implements of modern savages, but also all objects from other caves likely to aid these researches.

Mr. Lloyd's notes on the Reindeer of Newfoundland, contained in the last part of the "Reliquiæ," are most valuable as throwing great light on the habits of this ancient and widely-distributed Northern type.

We reproduce from page 279 of the "*Reliquiæ Aquitanicæ*" (by permission) in our Plate the incised figure of a Reindeer, cut on a piece of Reindeer antler, from the Kesslerloch, a Cave, or Rock-shelter near Thäingen, Canton of Schaffhausen, Switzerland.

This is probably one of the best examples of incised outline figures on bone metwith in any cave, and well deserves careful study. (See Plate XV.)

The one-holed Baton, Pogamagan, or *Arrow-straightener* (broken), which bears this remarkable engraving, is figured in the "Mittheil. Antiq. Gesellsch. Zurich," vol. xix. Heft 1, 1875, pl. 8, fig. 68, among the many interesting illustrations of Herr Konrad Merk's memoir, "The Cave-find in the Kesslerloch," etc. We are glad to be able to announce that Mr. John E. Lee, F.S.A., F.G.S., is about to re-publish this Swiss work as an English book with all the plates.

EXPLANATION OF PLATE XV.

Incised outline of a Reindeer on a piece of the round shaft of a Reindeer antler from the Kesslerloch Cave or Rock-shelter near Thäingen, Canton of Schaffhausen (natural size).

The surface of the cylindrical and engraved piece of antler is here shown as if extended open:—

A, A, the side with the figure of the Reindeer;

B, B, the other side bearing incised marks, probably representing herbage and water.

a, *a*, mark a line between the two sides of the engraved antler.

II.—Manual of Natural History, Geology, and Physics; and Instructions for the Arctic Expedition, 1875. 8vo. pp. 86 and 783. (London: Eyre & Spottiswoode.) First Notice.

FEW fields of geographical discovery, indeed few branches of scientific research, have either excited such abiding interest or had such an ancient and continuous history as that of Arctic Expeditions.

The difficulties that lie in the way of explorers in the more northern seas, and the ignorance which necessarily exists as to the geographical and meteorological phenomena of the unknown area surrounding the North Pole, have been incentives to other nations besides our own to solve the mysteries of the Arctic Regions.

The voyage of the *Polaris,* under Captain Hall, and that of the *Germania* in 1869-70, under Koldewey, were both evidences that the spirit of arctic discovery was by no means dead; but since the expedition of Sir Leopold McClintock in the *Fox,* in search of the missing crews of Franklin's ships in 1857-9, no important effort has been made under the auspices of the English Government to make one more attempt to penetrate the unknown lands, and set at rest, if possible, the eager spirit of scientific inquiry which lies at the foundation of such researches.

The discoveries of the *Polaris* and *Germania,* however, seem to have aroused anew the desire of the English nation not to be behindhand in the great work. At the close of 1874 the Government decided to take the matter in hand, and by its powerful assistance enable an expedition to be despatched, which should, from its careful and complete preparation, depart on its mission under better auspices and with greater chance of success than had fallen to the lot of any previous squadron.

The *Alert* and *Discovery* were therefore purchased and prepared, strengthened and fitted with every modern appliance which could either lessen the difficulties or lead to the success of the object in view, *not* merely the planting of the British flag on the northern axis of the earth, but to increase the knowledge of the Physical Geography of the Arctic regions, and add, therefore, to the scientific knowledge of the world.

Recent voyages had led to the conjecture that the path offering the greatest chances of success in the effort to reach the Pole was by the long, narrow, area of water which bounds the Western Coast of Greenland, known as Smith's Sound.

The President and Council of the Royal Society were informed by a letter from the Secretary of the Admiralty, dated 4th Dec. 1874, that it was their Lordships' intention to despatch an expedition, in the spring of 1875, to endeavour to reach the North Pole, and to explore the coast of Greenland and adjacent lands, and were invited to offer any suggestions which "might appear to them desirable in regard to carrying out the scientific conduct of the voyage." The result of this appeal is the volume of some 800 pages to which we purpose calling attention.

It is divided into two separate and distinct sections: (1) Instructions for future Observations, compiled under the direction of a Committee of the Royal Society; and (2) A Manual of Scientific Results already obtained in previous Arctic Expeditions, edited by Professor T. Rupert Jones, F.R.S. (who himself prepared the part relating to Zoology, Botany, Geology, and Mineralogy), and assisted by Professor W. G. Adams, F.R.S., who compiled the part relating to Physics.

Both sections are prepared with exceeding care; and the second part, or "Manual," contains the most complete and perfect collection of the most important information extant on the scientific researches in the Arctic Seas.

The first section, which is further subdivided into two parts, deals first with Astronomy, Terrestrial Magnetism, Meteorology, Atmospheric Electricity, Optics, etc., and secondly with Zoology, Botany, Geology, and Mineralogy; but it must be understood that this section of the book is designed solely to point out what information is required, and also the best means of obtaining it. Thus the early sections refer chiefly to the methods of obtaining local mean time and so on from eclipses, the necessity for repeated and accurate tidal observations, as well as the detection of the cosmical dust found frequently in the snow of northern regions, and which, being composed of iron and nickel, points to a meteoric or non-terrestrial origin.

The declination, inclination, and intensity of the earth's terrestrial magnetism, whereby the "knowledge of the distribution of the magnetic force over the earth's surface" may be determined, may lead to valuable results, contributing towards the perfection of our knowledge of terrestrial magnetism. The instruments requisite for these determinations, as well as the order in which observations should be made, are hence referred to, and the importance of this subject, as dealing with compass variations and the consequent security of iron shipping, needs no comment.

In fact, the whole of the first section deals rather with suggestions than with known facts, and details the manipulation of instruments for Meteorological and Atmospheric, Electrical as well as Optical and Spectroscopic observations, providing also technical maps bearing on some of the subjects.

Under the head of Miscellaneous Observations are some valuable remarks and suggestions by Dr. Rae and Professor Tyndall. The former deals with the salinity of ice, and the kinds which are most useful as a source of water-supply for drinking purposes, and points out that it is possible to procure "almost always" good drinking water from "wasted old ice," which must not be confounded with "rotten ice," as the latter is spongy, comparatively thin, saline, and unsafe to travel on, while the former breaks into detached floes when quite thick and solid. This rotten ice is worn away whilst *in situ* by sea-currents acting on its under surface; while the upper, owing to the low temperature of the air, is not affected; but it was suggested by Dr. R. Brown that this alteration may further be due to the accumulation of Diatomaceæ below the surface, which would tend to increase the local heat and be therefore perhaps another cause of the phenomenon to which Dr. Rae refers. Be the cause what it may, the fact itself is of considerable importance when the water-supply in an ice-bound region fails, and the determination of that kind of ice whence good water could be obtained is not merely interesting, but might be of considerable utility to those vessels which frequent the Northern seas.

Professor Tyndall's remarks, suggested by his own laborious researches, call especial attention to the formation of snow crystals and the rapidity of the conduction of heat through ice, and the action of the great Arctic glaciers. It is still a disputed point whether the icebergs are formed by the uplifting action of the water when the ice mass projects into the sea, in which case the surface being in a state of longitudinal compression, and therefore devoid of crevasses, or by the gravity of the overhanging end, when such fissures must naturally be formed. Some suggestive remarks on the method of determining the range of sound conclude the paper, to which Prof. Tyndall has appended copies of his valuable papers on the "Physical Properties of Ice," the "Atmosphere as a Vehicle of Sound," and "Forms of Water," which will doubtless furnish many important hints to those who accompany the Expedition.

Part II. of the first section of the book is devoted to Biology (Zoology and Botany), and Geology and Mineralogy. The first portion is purely for guidance in collecting the Mammalia, Birds, Fishes, Crustacea, Mollusca, Polyzoa, Hydroids, etc.; and for the determination of the more important varieties careful lucid descriptions are given; while the various points of interest about which our knowledge is still imperfect are fully noted. The completeness of this section, as a guide to, perhaps in some instances, inexperienced collectors, is very noticeable; and its value is enhanced by a brief but pertinent paper by Professor Huxley, calling particular attention to Microscopic collections of various kinds, but particularly those which could lead to a comparison between the microscopic Fauna and Flora of the surface-waters of the sea and those of the sea-bottom, to be obtained by dredging from the same localities.

The botanical section, by Dr. J. Dalton Hooker, consists of but one paper, but contains all the necessary information for procuring and preserving the flowering plants, mosses, lichens, and fungi, as well as the fresh and salt-water algæ of the Arctic regions; and concludes with a reference to the excellent opportunities afforded to the naturalists of the Expedition for "making observations on the power of seeds to resist cold whilst retaining their vitality." Seeds of various sorts, such as mustard, cress, radish, turnip, pea, bean, etc., have been provided for such experiments.

The "Instructions" close with some twenty pages of excellent matter referring to practical work in geology, mineralogy, etc. The names of Ramsay, Evans, Story-Maskelyne, and Judd are sufficient evidence of the value and importance of this sub-division of the introductory matter. The instructions and suggestions would be useful to any one, and comprise not merely a list of the tools and stock required for collecting and preserving, but good sketches of inclined, contorted, and other strata, conformable and unconformable stratification, and the like. It is unnecessary to call attention to these suggestions in detail, as they are numerous and terse, and to make an abstract of them would be impossible. Special attention is, however, called to the want of information on the Oolitic fauna, similar to that of Cook's Inlet discovered by McClintock in lat. 60°, and the Liassic fauna found both by Sir Edward Belcher and the Swedish Expedition in 78° 30′, and also whether a true Carboniferous flora occurs in any continental land or island, resembling that found in Bear Island. The examination geologically of the northern realms has hitherto been so very partial and incomplete, that a connected geological history is at present impossible. All that is really known is that a Miocene flora has been collected at Atanekerdluk and other places on the Waigat, at Disco, and Spitzbergen, and that many great sheets of basaltic lava overlie the rocks containing the Miocene plants in many places. As the Miocene igneous rocks of the Faroes and Inner Hebrides occur in much the same way, and the true determination of the position of similar deposits would not only throw "much light on the change of climate, but also on the subject of a great continental extension of land during the Miocene Epoch into far northern regions, as suggested by Dr. Robert Brown."

There is an interesting subject for research, too, in the character of the Greenland glaciers, namely, that the underlying rocks are not grooved or striated (as far as we at present know), like the rocks which have been acted upon by old or modern glaciers in the Alps and elsewhere. This apparently arises from the fact that the whole of Greenland has been entirely covered by the glacier-ice, so that no moraine matter from exposed cliffs or peaks could get between the ice-sheet and the underlying rocks, and act as agents for scoring or scratching the surface over which they were moved under great pressure. It is asserted, therefore, that the rocks are "ice-polished or '*moutonnée,*' but not grooved or scratched;" and it would be instructive to have accurate data on this point, so as to increase our knowledge of the action of glacier-ice under the exceptional conditions that obtain in Greenland.

The opening chapter or chapters of the Arctic Instructions and Manual may therefore be summed up as a code of excellent rules for the guidance of the scientific observers of the *Alert* and *Discovery*. They would certainly be most useful to those who, while fully conversant with one particular branch of science, may not have previously had the desire or opportunity of paying more than a passing attention to other branches. They would bring definitely before such an observer what to look for, and what to do when he had found the object of his search.

As such they are useful and interesting to others besides the able observers of the Arctic Expedition. C. C. K.

III.—Sulphurets: what they are, how concentrated, how assayed, and how worked. By W. Barstow, M.D. (San Francisco, A. Roman & Co.; London, Trübner & Co.)

THIS little book is chiefly intended for the Californian miner, and its object is to present to the reader, in a simple and concise form, the nature and treatment of the Sulphides of the metals, so as to save him, to some extent, the trouble of wading through a series of expensive works in which the subject-matter is more fully treated. The metallic sulphides, or sulphurets, are an important group of mineral compounds; those which occur most abundantly in nature are the sulphides of antimony, mercury, silver, zinc, lead, copper, and iron. Those of the latter are of most frequent occurrence, and are the source of some of the gold. Most gold-bearing rocks are coloured by the oxyd of iron, and that oxyd is often plainly derived from decomposed pyrites, which is found very generally associated with gold, although not chemically combined with it. However, gold is often found in rock which not only contains no pyrites, but is also perfectly free from discolouration.

The characters of the chief sulphides are very briefly described, too brief indeed to give their distinguishing characters. The second part gives a very concise account of assaying the sulphides, and also gold and silver, by the dry and wet methods. The third part describes the various processes and machines for separating the richer portions of the pulverised ore and other matters not desirable to work, and termed *concentration*; and the fourth part contains the different methods for the reduction of the sulphides, by which the metals they contain are extracted. The last part is devoted to a brief account of the different ores when assayed by means of the blowpipe, and their reactions with the various reagents to which they are submitted. It seems to have been the author's wish to make this an introductory guide to the more extensive and elaborate works on the same subject. J. M.

IV.—GUIDE TO THE GEOLOGY OF LONDON AND THE NEIGHBOURHOOD. By WILLIAM WHITAKER, B.A., F.G.S. 8vo. pp. 72. (Geological Survey of England and Wales, London, 1875.)

THIS little work is intended as an explanation of the Geological Survey Map of London and its environs, which was noticed in the GEOLOGICAL MAGAZINE for May last, page 231; and also of the Geological Model of London constructed under Mr. Whitaker's superintendence (noticed in the MAGAZINE for 1873, Vol. X. page 513), and now exhibited in the Survey Museum.

The work is confined to a general account of the geology, as details have either been already published in Mr. Whitaker's large memoir on the Geology of the London Basin, or will be given, so he states, in a future memoir on the drifts of that area.

The lithological features of the various formations are described; the leading fossils are mentioned; while the range, features, and scenery, are also briefly noticed; and lists of sections are given. The work is written very concisely and systematically, and from the number of interesting facts contained in it, it forms the best and most useful summary of London geology that has been published. It is probably the cheapest geological survey memoir for its size—the price being one shilling!—H. B. W.

V.—PRINCIPES DE GÉOLOGIE TRANSFORMISTE, APPLICATION DE LA THÉORIE DE L'EVOLUTION À LA GÉOLOGIE. Par GUSTAVE DOLLFUS. 8vo. pp. 178. (Paris: Librairie F. Savy.)

AS may be seen from the title of this work, the endeavour of the author is, to extend the theory of evolution, hitherto confined to organic life alone, and to apply it to stratigraphical geology.

This is not the first time that an attempt has been made to draw a parallel between the organic and inorganic world, nor is it in any way more successful than other such previous efforts.

M. Dollfus commences by stating the opinions of, and quoting from the most eminent geologists, past and present, with respect to the fixity or non-fixity of species.

In the second part, he briefly reviews each geological period, giving and commenting on the various opinions held concerning debated points; and especially remarking upon the modifications which the several faunas undergo in their passage upwards. With each formation is also given a table wherein the various beds of which it is composed in the different countries of Western Europe are, as far as possible, correlated.

In the third part, under the heading "L'Espèce en Stratigraphie," the author expresses his idea more clearly. This seems to be, that every bed, like an organized being, passes, so to speak, through certain phases of existence.

Its deposition is its birth, it then undergoes a series of metamorphoses until it reaches a stage in which it attains its full growth and ceases to alter. Thus Lignite passes into Coal and then Graphite; Limestone into semi-crystalline Limestone and then into saccharoid

Limestone. Finally it dies a natural death, being carried off by atmospheric or other agencies.

Further on M. Dollfus gives the laws of Hæckel, applying them as far as possible to his theory as well, which, owing to their nature, is easy; and with the exception of the third he succeeds in making out a kind of analogy. He concludes with some broad reflections on the progress and future of Geology.

We cannot, however, agree with the author either in his main point, or in several minor questions, which occur in the course of his book; though its perusal has afforded us much pleasure.—B. B. W.

REPORTS AND PROCEEDINGS.

Geological Society of London.

Opening Meeting, Session 1875–76.—November 3rd, 1875.—John Evans, Esq., V.P.R.S., President, in the Chair.—The following communications were read before the Society:—

1. "On some new Macrurous Crustacea from the Kimmeridge Clay of the Sub-Wealden Boring, Sussex, and from Boulogne-sur-Mer." By Henry Woodward, Esq., F.R.S., F.G.S.

The first species described by the author belonged to the fossorial family Thalassinidæ, six species of which belonging to four genera are now found on the British coasts. The known fossil species are from the Chalk of Maestricht, the Greensand of Bohemia and Silesia, the Chalk of Bohemia, the Greensand of Colin Glen, near Belfast, and the Upper Marine Series of Hempstead, Isle of Wight. All these are referred to the genus *Callianassa*, which also includes the species from the Kimmeridge Clay described in this paper. The fossil is seen in profile on several sections of the core, and has the enlarged hands of the fore-limbs more nearly equal in size than in the living species of *Callianassa*; the carapace and segments of the abdomen are smooth, and the latter are somewhat quadrate in profile, contracted at each extremity, and not pointed, and the caudal plates are oval. For this Crustacean the author proposes the name of *Callianassa isochela.*

The second species described belongs to the genus *Mecochirus*, distinguished by the great length of the fore-limbs, which is equal to that of the whole body; the oldest known species of which (*M. olifex*, Quenst.) is from the Lower Lias of Württemberg. It was obtained, together with *Lingula ovalis*, from the Kimmeridge Clay of Boulogne, by Mr. J. E. H. Peyton, after whom the author proposes to name it *M. Peytoni.* In this species the fore-legs are very finely punctate, and measure 75 millims. in length. The rostrum is somewhat produced, and the carapace, which is finely granulated, measures 30 millims. in length. The antennæ are long and slender. The abdomen measures 45 millims., and the epimeral borders of the segments are falcate. The species is intermediate in size between *M. socialis*, Mey., and *M. Pearcei*, McCoy, which the author regards as distinct. He also refers to *M. Peytoni* a pair of fore-limbs obtained from the Sub-Wealden boring.

2. "On a new Fossil Crab from the Tertiary of New Zealand." By Henry Woodward, Esq., F.R.S., F.G.S.

In this paper the author described a crab obtained by Dr. Hector, F.R.S., Director of the Geological Survey of New Zealand, from the "Passage-beds" of the Ototara series in Woodpecker Bay, Brighton, on the west coast of the south island of New Zealand. The new species belongs to the genus *Harpactocarcinus*, A. Milne-Edw., which includes six species from the Eocene of southern Europe. Its nearest ally is *H. quadrilobatus*, Desmar., but its carapace is much more tumid, especially on the branchial and gastric regions; the surface of the anterior half of the carapace is nearly smooth, and that of the posterior half finely granulated. The rostrum is short and very obtusely tricuspidate; the orbits shallow and rounded; the hepatic margin rounded and entire, with only a slight spine on the epibranchial angles; the divisions of the regions of the carapace are only faintly indicated; and there is a slightly roughened line on the sides of the gastric intumescence. The characters of the jawfeet and of the chelæ agree with those of the *Cancridæ*; of the latter the right is considerably larger than the left hand. The specimen was a female. For this species the author proposed the name of *Harpactocarcinus tumidus*.

Dr. Hector explained the sequence of formations in the locality from which the above Crab was derived, and stated that the Ototara series is to be regarded as Cretaceo-Tertiary, containing some fossils of decidedly Cretaceous type, such as Saurian bones and fragmentary *Inocerami*, and other forms that are associated with decidedly Mesozoic fossils in the underlying strata. On the other hand, the occurrence of Tertiary forms such as *Nautilus zic-zac* (or a nearly allied form), the gigantic Penguin (*Palæeudyptes antarcticus*, Huxl.), and a Turtle, indicate a fauna not unlike that at present existing in the vicinity.

3. "On a remarkable Fossil Orthopterous Insect from the Coal-measures of Britain." By Henry Woodward, Esq., F.R.S., F.G.S.

The author commenced by indicating the importance of the examination of the Clay-ironstone nodules of the Coal-measures, in which so many valuable fossils have been discovered, including the remarkable insect described in the present paper. The specimen displays the characters of the four wings, only two of which, however, are nearly perfect, and these measure $2\frac{1}{4}$ inches in length and 1 inch and $1\frac{1}{4}$ inch in breadth, the hind wing being the broadest. The author described in detail the characters presented by the venation of the wings, which includes three straight veins running parallel to the fore margin, the third bifurcating near the apex, a fourth much curved vein giving origin to six branches, and having at its base a triangular space, from which arise the other veins of the wing. The body appears to have been about 5 lines broad between the bases of the wings. In front of the wings is the prothorax in the form of two large, rounded, dilated, and veined lobes; it measures 14 lines across and 6 lines in length. In front of these lobes is the head (with its eyes) produced in front into a slender process three lines long. This insect is considered by the author to be most nearly related to the Mantidæ, the characters of the head and thorax especially being to some extent paralleled in the existing genus *Blepharis*. The author proposed to name the species *Lithomantis carbonarius*, and suggested that *Gryllacris* (*Corydalis*) *Brongniarti* probably belongs to the same genus.

4. "On the Discovery of a Fossil Scorpion in the English Coal-measures." By Henry Woodward, Esq., F.R.S., F.G.S.

The author commenced by noticing the various European and American localities in which fossil Arachnida have been found in the Coal-measures. Hitherto no true Scorpions have been recorded from the English Coal-measures; but in 1874 the author received from Dr. D. R. Rankin a specimen from the Coal-measures near Carluke, which he regarded as the fossil abdominal segment of a Scorpion; in April last he obtained (through Mr. Hy. Johnson, C.E., Dudley) a fossil Scorpion from the Sandwell Park Colliery; and in August Mr. E. Wilson forwarded to him two specimens of similar nature in Clay-ironstone nodules from Skegby New Colliery, near Mansfield. The specimens are all very imperfect; but the author states that they most closely resemble an Indian form which is probably *Scorpio afer*. He refers the English species provisionally to the genus *Eoscorpius*, Meek and Worthen, and proposes to name it *E. anglicus*.

Discussion.—Mr. Charlesworth inquired whether the few Cretaceous fossils found in the deposit which had furnished the New Zealand Crab described might not be the result of the degradation of pre-existing rocks.

Dr. Hector replied that on stratigraphical grounds this could not be the case.

Mr. Charlesworth stated that he had been unable to ascertain the precise locality of the fossil Orthopterous insect described, but that he was informed by the gentleman from whom he received it that the nodule containing the specimen was picked up by a lady near Airdrie, Scotland.

Prof. Morris remarked that the New Zealand Crab was of especial interest. All the previously described species of *Harpactocarcinus* had been obtained from Nummulitic deposits in the south of Europe, and the same concurrence was observed in New Zealand. Similar phenomena occurred in Australia, where many species resembling European forms had been discovered by M'Coy.

Mr. Etheridge said that one of Mr. Woodward's papers demonstrated the value of the Sub-Wealden boring. He had examined the cores, and had come to the conclusion that the Oxford Clay was reached at 500 feet; but in this he was mistaken, owing to his having wrongly identified the Ammonite discovered at that depth with *Ammonites Jason*. The occurrence of the same species of Crustacean at Boulogne and in Sussex was of great interest, as marking the identity of the deposit in the two localities. *Lingula ovalis* occurred with other fossils throughout the Kimmeridge Clay of the boring.

Mr. Woodward thanked Mr. Charlesworth for his endeavours to ascertain the locality from which his *Lithomantis* was obtained. There could, however, be no doubt as to its geological horizon.

5. "The Drift of Devon and Cornwall, its Origin, Correlation with that of the South-east of England, and Place in the Glacial Series." By Thomas Belt, Esq., F.G.S.

The author described the general characters of the drift in the district under consideration, and stated that on the uplands the drift consists of undisturbed gravels and travelled boulders, which occur only in isolated remnants on the lower ranges, and that in the lowlands and valleys within 100 feet of the present level of the sea the gravels are widely spread, and show signs of sudden and tumultuous action. Between the upland and lowland gravels he considered that great denudation had taken place. He maintained that the boulders and the materials of the gravels had been distributed by floating ice, and that their presence on the summit of Dartmoor indicated that the water on which the ice floated must have extended up to 1200 feet above the present sea-level; but he argued that this water was not that of the sea, because no old sea-beaches or remains of marine organisms are to be found in the region, although fresh-water shells are preserved. He ascribed these phenomena to the presence of a great freshwater lake, produced by the drainage of Europe being dammed back by a great glacier flowing from the north-west (Greenland) down the present bed of the Atlantic, and over the northern parts of the continent. The author discussed the characters of the superficial deposits in the southern and south-eastern counties, and indicated the points in which these seemed to bear out his hypothesis.

The sequence of phenomena assumed by the author is as follows:—Accepting Mr. Tylor's notion that the actual sea-level must have been lowered during the Glacial period in consequence of the great accumulation of water in the form of ice at the poles, he seeks a point of departure for the Glacial period in the first evidence of such a lowering of the sea-level. The Weybourne sands and the marine beds of Portland Bill were deposited when the sea was at about its present level, and the Bridlington Crag probably belongs to the same period. The fossils found in these deposits show that the waters were cold. The first stage of the Glacial period is that of the older Forest-beds, and the immigration of a number of great Mammalia and of Palæolithic man indicates that the sea had retired from the British Channel and the German Ocean, leaving these islands connected with the continent. A great river probably ran southwards through the region now submerged. The second stage is marked by the continued advance of the ice from the north, the retreat of the southern fauna and Palæolithic man, and the arrival of Arctic Mammals. The third stage saw the culmination of the Glacial period and the greatest extent of the Atlantic glacier, which reached to the coast of Europe, blocked up the English Channel, and caused the formation of an immense lake of freshwater by damming back the drainage of the whole of north-western Europe, as already indicated. In the fourth stage the Atlantic glacier began to retreat, and the sudden breaking away of the barrier of ice that blocked up the mouth of the Channel caused the tumultuous discharge of the waters of the great lake, by which the spreading of the lowland gravels was effected. To this cause the author attributes the formation of the Middle Glacial sands and gravels of Norfolk and Suffolk. During the fifth stage the ice of the German Ocean continued to retreat; but there was a temporary advance of the Atlantic glacier, which again blocked up the Channel, and produced a second great lake, which, however, did not attain so great a height as the first, and its waters were not discharged in the same tumultuous fashion. At this period the Upper Boulder-clay of Norfolk and

Suffolk was formed; but the author is not convinced that this formation is represented south of the Thames except by the "Trail" of the Rev. O. Fisher. In the sixth and last stage the Atlantic ice retreated as far as the north of Scotland, but the sea had not returned to its former level. The British Isles were connected with the continent and with each other. To this the author assigns the last great forest period, and the arrival of Neolithic man and the associated fauna from the continent.

Discussion.—Mr. Hicks stated that he had noticed that the glaciation at St. David's is from the north-west. He had already stated before the Society his opinion that there had been depressions proceeding from a point in the Atlantic, probably not far from the coast of South America, to the north-west and north-east; and this might perhaps have something to do with causing a flow of ice from Greenland to the south-west in North America and to the south-east in Europe.

Rev. O. Fisher wished to know what would be the area of the great freshwater lake supposed to be produced by the damming action of the great Atlantic glacier.

The Author stated that the area blocked up by the ice would be about 40,000 square miles (2000 × 200), and would include all the region drained by the present northern rivers.

Prof. Hughes wished to know why the waters could not drain off by way of the Black Sea, and why the advancing Atlantic glacier should be supposed to stop just at the western point of Cornwall. He could discover no evidence of there ever having been a lake such as the author described. The drift gravels were the result of all the agencies of denudation which had ever been at work, and the boulders at the bottom of the low-ground drifts were probably due to the fall of débris from the summits. The boulders of the drift, if the author's theory were true, ought to consist of Greenland rocks, whereas they were really of local origin. With regard to the direction of glaciation in Britain and Northern Europe being from the north-west, he could not agree with the author. In many places glaciation might be observed running in every direction; and it was not fair to note only certain striæ, and neglect those which were not in favour of a foregone conclusion. He thought that Mr. Campbell had shown clearly that the glaciation of Ireland took place from the north-east.

Mr. Moggridge remarked that a very flat country extended across the continent of Europe from England to the Black Sea, and thought that in that direction there was no land sufficiently high to form the boundary of such a lake as that required by the author's theory.

Rev. T. G. Bonney said that, in addition to the difficulties which Prof. Hughes had mentioned, four others at least occurred to him:—That the barrier to Mr. Belt's lake was defective between the highlands of Brittany and the Auvergne; that the ice in its course from Greenland would have to cross a part of the Atlantic where the depth approached 2000 fathoms, which seemed to demand an inconceivable accumulation in that country; and that under such circumstances Wales, Scotland, and Scandinavia must have had their own ice-systems; and that to reach Scandinavia (which certainly had its own ice-system), this great sheet must have crossed the Lofoten Islands, yet all the higher hills in these were remarkably sharp and broken. Further, in regard to what Mr. Belt had said about the lowering of the general level of the sea, it must be remembered that such an ice-cap would raise the level in the hemisphere where it occurred.

The Author, in reply, said that he did not want the ice to stop at Cornwall, but that his statement as to its limits was founded on observed marks of glaciation. He thought the absence of marine remains throughout the drifts of the northern plains of Europe was a highly important and suggestive fact. With regard to the glaciation of Ireland, he remarked that the ice flowing south-east from Greenland would strike against the high lands of Scotland and England, and be turned back over Ireland. The lowering of the sea was not absolutely required by the necessities of the paper; but if the accumulation of ice took place simultaneously at both poles, the sea must necessarily be greatly lowered.

CORRESPONDENCE.

CUP-SHAPED JOINTS OF BASALTIC COLUMNS.

Sir,—It is clear (from Mr. Mallet's letter to you, see Geol. Mag. Nov. 1875, p. 566, and also from his communication to "Nature" of this date) that no *facts* which may be adduced can be regarded as of any value, if they discountenance a 'cut-and-dried' theory on which a 'physicist' has made up his mind. He contents himself with simply reasserting his theory, and resolutely refuses to examine the appearances presented by the fine group of columns in the Hall of the Geological Society, to which I have referred him, as being totally inconsistent with it.

Mr. Mallet's theory presupposed, in his own words, that "the convex surface of the joint" should "always point in the same direction as that from which the cooling and consequent splitting proceeded" (p. 182 of Proceedings of Royal Society, No. 158). I ventured to submit this supposition, which did not agree with my experience, to the test of "facts." In the triple group of columns from the Giant's Causeway in the possession of the Society, in which there is every reason to suppose the cooling and splitting had proceeded throughout in one and the same direction, do the convex surfaces of their joints all point in the same direction? I found them, on the contrary, pointing in different directions. Nay, even in one column an articulation of little thickness showed two cup-shaped concavities pointing different ways, back to back, like those of a bi-concave lens. Now how does Mr. Mallet attempt to get over this difficulty? Why, by supposing, or rather asserting as a fact *proved by his theory*, that the cooling process *in this column* proceeded in opposite directions, from the top as well as the bottom, and met in the interval between the two opposite concave joints—that interval being an articulation only a few inches thick, and showing no sign of seam or separation across it! But, in addition to the obvious improbability of this supposition, Mr. Mallet has himself disposed of it in the following passage (page 183, Proc. Royal Soc. No. 158): "If the mass cools both from the top and the bottom, the prisms, vertical and straight, will meet in an irregular intermediate stratum *of angular fragments*."

I have already said that there is no appearance of any such intermediate fragmentary stratum within the very thin articulation in which Mr. Mallet, in order to save his theory, now chooses to place the separating plane between the portions cooled from above and from below.

In addition to the evidence furnished by the column in the Society's Museum, which, however, is quite conclusive on the question, I have the authority of my friend Mr. Judd, whose competency as an observer will not be disputed, for the fact that, in the platform of the Giant's Causeway, as well as at Staffa, there are to be seen at least as many concavities as convexities. And even Mr. Mallet will scarcely deny that in all these columns the cooling must have proceeded in the same direction; namely, from below upwards. Indeed the very regular columnar ranges, to which Mr. Mallet's theory relates, have, one and all, evidently cooled from the bottom; the upper portions of the basaltic beds being nearly amorphous, or, if prismatic at all, composed of very imperfect groups of prisms.

Apart, indeed, from Mr. Mallet's ideal columns, I will state, as the result of my own observations, that in every natural section of a basaltic columnar range, the plane separating the portion in which cooling probably began below from that in which cooling began at the upper surface, is, as a general rule, horizontal; the two portions being as distinct as is the architrave in a Greek temple from the supporting columns (as may be seen in any good drawing of Staffa, or of the basaltic columnar ranges of the Vivarais, Auvergne, etc.). The upper portion is, indeed, generally amorphous, or nearly so, and so decidedly separated from the lower regular columnar range, as to have been usually mistaken for a separate lava-flow of later formation. If Mr. Mallet's notion could be realized anywhere, it would be in the horizontal columns of a vertical dyke, formed by contemporaneous cooling from both of its sides. I will, however, venture to say that no instance can be produced of a single continuous column passing unbroken, from side to side, of any dyke. Can Mr. Mallet produce any example of such a fact from his own observations? The columns, on the contrary, always terminate towards the centre of the dyke, either in a seam of amorphous lava, or an interval filled with rubble (and this Mr. Mallet himself admits, as in the former instance, p. 183), or sometimes they are separated by a still more recent vein of lava. Finally, I leave it to all geologists interested in the question, to examine the columns in the possession of their Society, and form their own opinion upon the point in dispute between Mr. Mallet and myself.

It is of the more importance from its having an indirect bearing on the main question as to the influence of concretion, no less than of simple contraction, upon the production of the columns themselves: a question upon which, likewise, I have the misfortune to differ with Mr. R. Mallet, who will not admit of any concretionary action at all —even, for example, in the case of the nearly globular articulations of the prisms of the Cheese-Cellar at Bortrich. But upon this point, I will not here enlarge.

COBHAM, *November 3rd*, 1875. G. POULETT SCROPE.

ON THE PRESENCE OF THE GENERA *PLICATOCRINUS, COTYLEDERMA* AND *SOLANOCRINUS* IN BRITISH STRATA.

SIR,—At the British Association Meeting a few weeks since, F. Longe, Esq., F.G.S., of Cheltenham, handed to me a very perfect example of the interesting but little known Crinoid *Plicatocrinus* which had been found by him on the coast near Bridport. He informed me he had shown it to Dr. Wright, who had referred it to the family *Cirripedia*, to which at first sight it bears some resemblance.

I explained to Mr. Longe that this was incorrect, as it belonged to the *Crinoidea*, at which group Dr. Wright had so long been working, and that I was already possessed of several of the above genera and species from the same geological horizon as those previously found on the Continent. A notice of these appears in my paper on "Abnormal Conditions," etc., p. 480 of the Journal of the Geol. Society for 1867. Mr. Longe with much liberality presented me with the specimen.

After this I showed it to Dr. Wright, and pointed out to him the zoological position that had been assigned to it by continental geologists, and in reply to his inquiries informed him that the best figures and description would be found in a paper by Dr. Deslongchamps of Caen.

Dr. Wright lost no time in referring to Dr. Deslongchamps' description, for in a note to me on another subject, he remarks: "As I am always on the look out for any new facts to chronicle in relation to my own subject, I sent a short notice of Mr. Longe's discovery to the GEOLOGICAL MAGAZINE, and herewith inclose you a separate text." In this he quotes the history of *Cotylederma* as given by Dr. Deslongchamps, but makes no reference to the conversation I had with him respecting it. At this time I had no opportunity of seeing Dr. Deslongchamps' memoir, or comparing the specimen with those in my museum. On my return home I found it belonged to the genus *Plicatocrinus*, and not to *Cotylederma* as I had first supposed. Had I been aware Dr. Wright intended sending a notice of the specimen for publication, I could at once have corrected the error.

From his remark in the last paragraph that "it is the first English specimen of this curious form of the Liassic sea which I have yet seen from our Lias beds," he does not appear to be aware of its previous discovery by myself, though on one occasion, if I mistake not, I called his attention to examples in my museum, where they have been publicly exhibited.

I took with me to the Bristol Meeting a beautiful specimen of the genus *Solanocrinus* I have lately found in Oolitic strata, and now first recorded as a British genus, but withheld a notice of it in order to have drawings prepared of Mr. Longe's *Plicatocrinus*.

BATH, *Oct.* 25, 1875. CHARLES MOORE.

OBITUARY.

WILLIAM SANDERS, F.R.S.

Death has removed another of the small band of distinguished geologists that commenced their career when the science they cultivated and elucidated was yet in its infancy. The late Mr. William Sanders, F.R.S., was a native of Bristol, and for upwards of forty years of his life was intimately associated with the most distinguished names that have enriched geological science.

He devoted his life to the study of the physical structure of the Bristol area, and early in his scientific career was the friend and companion of Prof. Phillips in his Geological Survey of North Devon and Cornwall, which occupied some years. His chief labour, however, and that by which his name will ever be remembered, was the preparation and construction of an elaborate geological map of the area comprised within the Gloucestershire and Somersetshire Coal-field. The scale of this map is four inches to the mile (four times the scale of the Ordnance Map), and the detailed geological structure of the entire area was conscientiously and carefully worked out. The labour devoted to this map by Mr. Sanders extended over fifteen years, and the work occupies nineteen folio sheets geologically coloured, and the physical details added.

Sir Henry de la Beche and Professor Phillips in days long gone by urged upon Mr. Sanders the importance of constructing a map upon such a scale that the complicated structure of the Bristol Coal-Field should be so clearly expressed that its mineral wealth should be better understood and appreciated. It may be truly said that no man single-handed ever constructed such an exact geological map for any area. Associated with this map should be mentioned another original and lasting labour by Mr. Sanders, viz. the measured sections of the extensive cuttings (delineated to scale) of the Bristol and Exeter Railway from Pyle Mill, Bristol, to Uphill on the Mendips, and the line from Bristol to Bath, in both of which the smallest details are laid down, whether of Physical or Palæontological value. Their value remains undiminished, although done thirty-five years ago.

Few there are who can appreciate the patient labour, ability, and mental culture required to carry out and complete so extended a survey over so complicated a region. These labours, however, added to his other acquirements, made his scientific reputation and enriched his native city.

Mr. Sanders rendered great service to Bristol in connection with the water-supply through his intimate knowledge of the water-bearing strata and resources in the Mendip area, and also during the survey of the city with reference to its sanitary condition: facts little known to those outside the world of science, and who have not, like Mr. Sanders, patiently pursued a line of study and research much in advance of their fellow-citizens. He was an ardent student in mineralogy, and few were more accomplished in crystallography. He mastered its mathematical details in the elaborate treatises of Brooke and Miller, Dana, and Naumann.

Mr. Sanders was elected a Fellow of the Royal Society in 1864. For upwards of thirty years he held the office of honorary secretary to the Museum of Natural History attached to the Philosophical Society and Institution of Bristol. He spared neither time, trouble, nor expense to carry out its legitimate objects. Mr. Sanders' labours and researches have contributed in no small degree to the development of geological science, and the sheets of his large map formed the basis upon which the materials accumulated by the Royal Coal Commission relative to the Gloucestershire and Somersetshire Coal-fields were represented. His name will ever be associated with the labours of the great and good in science, and those who knew him best will most deeply mourn his loss. R. E.

INDEX.

STEPHEN AUSTIN AND SONS, PRINTERS, HERTFORD.

Date Due

MAY 1970	