Address to the Geological Society, delivered at the Anniversary, on the 17th of February, 1837, by CHARLES LYELL, JUN., *Esq., President.*

GENTLEMEN,

You will have learnt from the Treasurer's Report that the finances of the Society are flourishing, and they would have appeared in a still more prosperous condition, had we not expended above 500*l.* within the year on our Transactions. Part of this sum has already been repaid by the sale of the volume just published, of which I may safely say that it yields to no preceding number in the value of its contents or the extent and beauty of its illustrations.

The total number of Fellows of the Society, exclusive of Honorary and Foreign Members, at the close of the year 1835, was 670; at the close of 1836, 709; being an actual increase, after deducting 14 for deaths, removals, and resignations, of 39 Fellows*.

We have to lament the loss of Dr. Henry, of Manchester, so highly distinguished as a chemist and philosopher, and who took a warm interest in the progress of our science. Our list of Foreign Members has been diminished by two deaths, those of Professor Hoffmann of Berlin, and Baron Férussac of Paris.

Professor Frederick Hoffmann was suddenly cut off in his 39th year, at the moment when the scientific world were impatiently expecting his account of the Geology of Sicily. You are probably best acquainted with him as the author of the great Geological Map of Western Germany, in which he made known the results of many years of patient and accurate research. This Map, published in 1829, was divided into twenty-four sheets, and was followed in 1830 by an Atlas containing sections, and a more general map on a smaller scale of the same country. In the same year the author's Geography and Geology of North-western Germany appeared†, which may be regarded as a commentary on the great map, comprising a descrip-

* The return of the number of Fellows, and the deaths alluded to in this Address, refers exclusively to the year 1836, and not to the period intervening between the last and present Anniversary.

† Orograph. und Geognost. Verhältnisse vom Nordwestlichen Deutschland, 2 vols. Leipsig, 1830.

tion of the physical outline of the country, its mountains, valleys, plains, and river-courses, and a sketch of a portion of its geological structure, embracing the transition and secondary rocks of the Hartz, Thuringerwald, and Lower Rhine. In the larger map all the tertiary and alluvial deposits are represented by one colour, the author having never entered upon the subdivision and classification of these formations. He had studied, however, the newer secondary formations, which were depicted by several distinct colours, and their history would have been included in the work above alluded to, had he not been interrupted by his tour in Italy and Sicily in 1830.

Among his other writings, I may enumerate an Account of Magdeburg, Halberstadt, and the adjoining territory, and various papers which will be found scattered through the journals of Poggendorff and Karsten, the Hertha, and other German periodicals. The only fruits which we as yet possess of the scientific expedition sent by the Prussian Government under Hoffmann's direction to Italy and Sicily, are some letters written by him during the journey, and an excellent Memoir on the Lipari Islands; and a valuable work by one of his companions, Dr. Philippi of Berlin, who published in Latin a detailed account of the recent testacea of Sicily, and the tertiary fossil shells collected in the course of the expedition*.

From Hoffmann's letters it clearly appears that the novelty of the volcanic and tertiary phænomena of Southern Italy and Sicily had made a deep impression on his mind. He had been astonished, on recognising the identity of the modern trap rocks of the Val di Noto with those of ancient date in Germany, and the no less striking similarity of the Sicilian tertiary limestones, containing recent shells to many calcareous secondary formations of northern Europe. The Lipari Islands afforded him a field for the examination of modern igneous rocks, and the slow effects of volcanic heat in modifying aqueous deposits. The picture which he has given of the fumeroles of the western coast of Lipari, the principal island of the group, is graphic and highly instructive. At St. Calogero numerous fissures are seen permeated by heated vapours which are charged with sul-

* Philippi, "Enumeratio Molluscorum Siciliæ tum viventium tum in tellure tertiaria fossilium, quæ in Itinere suo observavit Auctor." 280 pages 4to, and 12 lithographic plates, Berlin, 1836.

phur, oxide of iron, and other minerals, in a gaseous state. Here the tufaceous and other rocks are variously discoloured wherever the steam has penetrated, and are sometimes crossed with ferruginous red stripes, so as to assume a chequered and brecciated appearance. In one place a felspathic lava has been turned by the vapours into stone as white as chalk marl, in another, a dark clay has become yellow or snow-white, and these effects are not limited to a small space, but are seen extending for four miles through horizontal strata of tuff, which rise occasionally to the height of more than 200 feet. The greater part however of the alterations are referred to what are properly called extinct fumeroles, or the action of volcanic emanations which have now ceased, but which must at one period have resembled those of St. Calogero. Some of these have produced veins of fibrous gypsum, calcedony, and opal, minerals which must have been introduced into the rents in a state of sublimation.

In some places there are tufaceous marls, regularly alternating in thin beds, with still thinner and countless layers of granular gypsum, the whole mass being again run through everywhere by irregular branching veins of silky fibrous gypsum. These strata, thus intersected, present a perfect counterpart to some of the secondary gypseous marls, both of the keuper and variegated sandstone formations in Germany*.

When reading the Professor's description of these phænomena, we share in the pleasure and surprise which he felt on comparing strata of high antiquity with others of so recent a date, and which, moreover, owe a portion of that resemblance to changes now daily in progress.

The writings of Baron Daudebard de Férussac were not devoted principally to Geology, but we are indebted to him for several memoirs, and among others for an Essay, published in 1814, on fresh-water formations, with a catalogue of the species of land and fresh-water shells which were then known to enter into their composition. Monsieur de Férussac contributed largely to the Geological section of the Bulletin Universel des Sciences Naturelles, a journal, of which

* Liparischen Inseln, p. 41. Leipzig, 1832.

he was the chief editor and original projector. This Bulletin had, for its object, to give a monthly analysis or brief abstract, usually unmixed with criticism, of the contents of all new publications in every department of science. The work was first carried on for a year on a smaller plan, and then assumed in 1824 its enlarged and permanent form, being divided into eight sections, one of which was devoted to Geology, Palæontology, and Natural History. A monthly number appeared regularly, on this and each of the other seven sections, the whole forming together a large octavo volume. In the organization and direction of this scheme, the Editor was indefatigable, and he succeeded in obtaining the co-operation of a great number of the most able and eminent writers. In announcing the original aim and scope of the undertaking, he laid stress on the difficulties under which men of science labour in procuring intelligence of new works, written in a great variety of languages in different parts of the world, and frequently buried in the voluminous and costly transactions of learned societies. He therefore expressed a hope that his Bulletin would serve as "a kind of telegraph" for the rapid conveyance of the earliest intelligence of inventions and discoveries, so as to prevent philosophers from wasting their time and money in slowly feeling their way to results already found out by others, and attaining with great labour the very points from which they might have started. The Geological section of the Bulletin was ably supported by MM. Boué, Brongniart, and other writers, and survived the other sections for some time, maintaining itself for seven years, till at length it was given up in 1831 for want of sufficient encouragement.

The works of Baron Férussac on Natural History, and especially Conchology, would deserve from me a fuller notice, if they were not irrelevant to the subject of this address.

HOME GEOLOGY.

I shall now commence my retrospect of the proceedings of the Society, during the last year, by considering those papers which have been devoted to the Geology of the British Isles. There is probably no space on the globe, of equal area, which has been so accurately surveyed as this kingdom; yet the most experienced

geologists are now exploring several parts of it with the feeling that they are entering upon terra incognita. Not only do they find it necessary to trace out more correctly the limits of formations previously known, but also to introduce new groups of fossiliferous strata and new divisions, in districts before supposed to have been well investigated.

The carboniferous deposits which are alike interesting, in a scientific and economical view, have deservedly occupied of late the particular attention of many able geologists, and we have received communications on the subject from Mr. Murchison, Mr. Prestwich, Professor Sedgwick, and Mr. Peile. The observations of Mr. Prestwich relate to the coal-measures of Coalbrook Dale, and the formations immediately above and below them, together with the accompanying trap-rocks.

There is perhaps no coal-field in the whole country of equal size in which the strata have been so much dislocated and shattered. Mr. Prestwich gives a detailed description both of the principal and minor faults, their direction, extent, inclination, breadth, and fall, and the difference of level produced by them in their opposite sides, which is sometimes slight, but sometimes amounts to 600 or 700 feet. In some instances the change of level is by steps or hitches, which, it is truly said, may be owing either to unequal resistance, or to a series of small dislocations. The walls of the fissures in the disjointed strata are sometimes several yards apart, the interval being filled with the debris of the strata. In other places they are in contact. In this last case it is particularly remarked that the surface of the ends of the fractured beds of coal and shale is shining and striated. You are aware that this appearance has usually been attributed, and I believe rightly, to the rubbing of the walls of the rent one against the other, the lines of the polished and striated surfaces indicating the direction of the motion, but I have lately seen it objected to this theory, that the striæ are not always parallel, but often curved and irregular, and that the earthy contents of veins and faults often present the same glittering and striated faces, or slickensides as they have been called. I am familiar with the fact, and have always inferred that the movements were irregular and complicated, occasionally changing their direction, and that even when uniform, they may have acted unequally on mate-

rials varying in hardness and pliability. It is much to be desired that scientific travellers who visit countries shaken by earthquakes would observe with minute care all the phenomena attending the fissuring of rocks and buildings. I have been informed by an eye-witness of one of the late minor earthquakes in Chili, that the walls of his house were rent vertically, and made to vibrate for several minutes during each shock, after which they remained uninjured and without any opening, although the line of the crack was still visible. On the floor, at the bottom of each rent, was a small heap of fine brickdust, evidently produced by trituration. In such instances it would be desirable to obtain fragments of the rent building, and to compare them with the walls of natural fissures.

In his examination of the fossils of the coal-measures, Mr. Prestwich has shown that beds containing marine remains alternate with others in which fresh-water shells and land plants occur, appearances which he attributes to the flowing of a river, subject to occasional freshes, into the sea, rather than to repeated changes in the relative level of land and sea.

It is certainly the safer course to incline to this hypothesis whenever there are no unequivocal signs, as in the Purbeck strata in Portland, of land plants having become fossil on the very spots where they grew. For although there may be many river deltas like that of the Indus, where the land is subject to be alternately upheaved above, and then let down below the waters of the sea, yet such oscillations of level must be considered as exceptions to the general condition of the earth's surface near the mouths of rivers at any given period. Even in a case like the delta of the Indus, both the causes above alluded to may be expected to co-operate in producing alternate fluviatile and marine strata; for in the long intervals between great movements of the land, the river will annually advance upon the sea with its turbid waters, and then retreat again as the periodical flood subsides, and the salt waters, after being driven back for a time, will reoccupy the area from which they have suffered a temporary expulsion.

In the conclusion of his valuable paper, Mr. Prestwich observes that the carboniferous strata of Coalbrook Dale must once have been entirely concealed under a covering of new red sandstone, and they owe their present exposure partly to those movements

which have shattered and elevated the coal measures, and partly to extensive denudation. It is natural therefore to inquire how many other coal-fields may still lie buried beneath the new red sandstone of the adjoining district.

In relation to this point of great practical importance, Mr. Murchison formerly offered some conjectures, when speaking of the probable passage of the 10-yard coal of the Dudley field beneath the new red sandstone, which there flanks it on the east and west. That geologist now informs us that his conjectures have been verified, and that at Christchurch, one mile beyond the superficial boundary of the coal-field, the 10-yard and other seams have been reached by borings carried down to the depth of nearly 300 yards. Adverting to this discovery, he directs attention to the possible extension of other carboniferous tracts beneath the surrounding new red sandstone of Shropshire, Worcestershire, Staffordshire, and other central counties.

It is clear that these geological considerations must be duly weighed by those who speculate on the probable future duration of British coal, according to the actual or any assumed rate of consumption.

Mr. Murchison, in describing the Dudley and Wolverhampton coal-fields, informs us that he has not yet found any fossil remains of decidedly marine origin, like those observed by Mr. Prestwich in Coalbrook Dale. The shells seem to be all of fresh-water genera, and the *Megalichthys Hibberti*, and other fish occurring at Dudley, of species identical with those of the coal measures of Edinburgh, may have inhabited fresh water.

The same author has coloured on an Ordnance Map the superficial area of the Silurian rocks connected with the coal-fields above mentioned, and has shown that the Lickey quartz rock between Bromsgrove and Birmingham, of which the geological position has remained hitherto uncertain, is in fact nothing more than altered Caradoc sandstone, a member of the lower Silurian group. The same appears as a fossiliferous sandstone in one district, while in another, it passes into a pure quartz rock, a modification attributed to the proximity of underlying trap, for analogous changes have been seen at neighbouring points where the absolute contact of the sandstone with the trap is visible.

We are also indebted to Mr. Murchison for some interesting remarks on the dislocations of the strata in the neighbourhood of Dudley, and particularly for a description of some dome-shaped masses, from the centre of which the beds have a quâquâversal dip. He speculates on the probable dependence of these phenomena upon the protrusion of volcanic matter from below, at points where it has been unable to find issue. It would, I think, have been more satisfactory, if, in confirmation of his theory, some natural section of one of these dome-shaped masses could be pointed out, where not only a nucleus of trap was apparent, but could be shown to have taken up its actual position in a soft or fluid state. Even if we should find in some instances a subjacent central mass of trap, porphyry or granite, not sending out veins or altering the strata, the folding of the beds round such a protuberance might admit of an explanation like that suggested by Dr. Fitton. He has supposed a set of yielding horizontal strata to be pressed upon by a subjacent hill or boss of hard rock, in which case the effect of upward pressure might resemble that seen, on a small scale, in the paper of a bound book, where a minute knob in one leaf has imparted its shape to a great number of other leaves without piercing through them*. Whatever hypothesis we favour, it is essential to observe that such hills as the Wren's Nest near Dudley, and others of similar ellipsoidal forms and internal structure, do not correspond to the type of volcanic hills, such as Etna, Mount Dor, or the Cantal. In both cases there may be an approach to a cone, and the beds may dip everywhere outwards from a common centre; but, in the volcanic mountain, the beds having an outward dip, thin off as they approach the base or circumference of the cone, which is not the case in inclined beds composing the hills alluded to in the neighbourhood of Dudley: nor in the last-mentioned instances do the lowest or subjacent rocks crop out round the circumference of the cone, as happens in the instance of the volcanic eminences before alluded to, where the granite of the country round Mount Dor, the fresh-water beds and mica schist in the Cantal, the marine deposits around Mount Etna in Sicily,—each appear at the surface as soon as we have left the slope of the cone, and advance upon the surrounding low country.

* Dr. Fitton, Geol. Trans. 2nd Series, vol. iv. p. 244.

In attempting to explain the principal transverse faults of the Dudley coal-field, Mr. Murchison refers frequently to the theoretical principles expounded by Mr. Hopkins in his Researches in Physical Geology, a paper printed in the 6th volume of the Transactions of the Cambridge Philosophical Society. Mr. Hopkins has there endeavoured to develop, by reasoning founded on mechanical principles, and by mathematical methods, the effects of an elevatory force acting simultaneously at every point, beneath extensive portions of the crust of the earth. He is aware that in nature such a force must usually act under complicated conditions, so as to produce irregular phænomena; but he observes that in order to have a clear conception of the manner in which it would operate in producing movements and dislocations, it is useful to assume certain simple conditions to which mathematical investigations may be applied. When we have deduced in this manner some results free from all uncertainty, these may serve as standard cases to which the geologist may refer more complex problems. Thus for example, a portion of the earth's crust may be assumed to be of indefinite length, of uniform depth, and bounded laterally by two vertical parallel planes, beyond which the disturbing force does not extend. It is then supposed that a quantity of subterranean vapour or melted rock, existing at a certain depth, is expanded by heat so as to elevate the superincumbent mass, the resulting fissures in this mass may then become matters of calculation. According to Mr. Hopkins, rectilinear lines of dislocation will give rise to a set of longitudinal parallel fissures, and simultaneously to others precisely at right angles to them; whereas in conical elevations, the fissures will diverge from a centre. If the general axis of elevation be curvilinear, the longitudinal fissures preserving their parallelism with it will be also curvilinear, while the transverse fissures being perpendicular to the former at their points of intersection will no longer be parallel.

To return from this digression, I must now recall your attention to other papers relating to the carboniferous deposits of England. The coal-measures of the north-western coast of Cumberland have been examined by Prof. Sedgwick and Mr. Williamson Peile, who have described the Whitehaven and other fields in great detail, illustrating their account with a map and sections. The recorded

observations in numerous sinkings and borings, both in relation to the succession of the strata and to the complicated faults which intersect them, would have been involved in hopeless confusion, if they had simply consisted of a statistical collection of facts attested by miners; but in this paper, Professor Sedgwick, aided by Mr. Peile's practical and scientific knowledge, has compared the different sections and generalised the phænomena, giving unity and consistency to the whole, throwing the strata into distinct groups, and referring the several faults to different movements to which successive periods of time may be assigned.

In connection with these recent contributions to the history of our carboniferous strata, I am happy to mention the excellent volume lately published by Professor Phillips, forming the second part of his Illustrations of the Geology of Yorkshire. It is almost entirely devoted to a description of the carboniferous or mountain limestone of Yorkshire and the North of England, a subject already admirably treated in some papers read before this Society by Professor Sedgwick, particularly in his account of the carboniferous chain from Penigent to Kirkby Stephen*. As these geologists had separately explored the same ground, it is satisfactory to perceive that the leading divisions which they have proposed for the classification of the mountain limestone and associated strata, agree in every essential point. Mr. Phillips has described the physical geography of the district occupied by these rocks, their lithological character, stratification, jointed structure, and the most remarkable faults which affect them, especially those which have been called the great Penine and Craven faults. He also treats of the trap dykes which cut through the limestone, and discusses the probable epochs of the displacement of the strata, judiciously pointing out the difficulties unavoidably opposed to the rigorous determination of the date of such dislocations. A large and very valuable portion of the work is filled with descriptions and plates of organic remains, especially of the brachiopodous and cephalopodous mollusca. Most of the species of these classes were probably inhabitants of the deeper parts of the sea, but there are fossil shells in the mountain limestone, which the author supposes

* Trans. Geol. Soc. 2nd Series, vol. iv. part 1. p. 69.—1835.

to have lived near the shore, and belonging to genera formerly regarded as foreign to the carboniferous limestone, such as Isocardia, Nucula, Pecten, Patella, Turritella, and Buccinum. Many species of Zoophytes and Crinoidea are also described and figured in this excellent monograph.

We are indebted to Mr. Austen for a description of the South of Devonshire between the river Ex and Berry Head, and between the coast and Dartmoor, a district consisting of transition rocks, new red sandstone, greenstone, and trap. His speculations on the origin of the different formations and the causes which gave rise to the existing features in the physical geography of the country display much talent and are full of instruction.

The structure of Devonshire has also furnished a fertile field of inquiry to Messrs. Sedgwick and Murchison since our last Anniversary. They have attempted the difficult task of establishing a classification of the older rocks so largely developed in that county. In every geological map hitherto published of Devonshire, all the stratified deposits of higher antiquity than the new red sandstone had been represented by one common colour, the limestones being all included as integral parts of one great formation called greywacke*. But these gentlemen, after examining this region, announced at Bristol to the geologists assembled at the Meeting of the British Association, that the great mass termed greywacke, and previously undivided, comprised in it several formations of great thickness, ranging in age from the Cambrian system of Professor Sedgwick up to the true carboniferous series inclusive. The first groups mentioned by them in ascending order are the Cambrian and Lower Silurian, which great mass contains many distinct courses of limestone; and is separable into several formations, distinguishable from each other by stratigraphical position and by lithological and zoological characters.

There appears, however, to be a great hiatus in the succession of rocks in Devonshire, as compared to South Wales, there being no

* The Abstract of the Report of Messrs. Sedgwick and Murchison, published with a section in the Athenæum, August, 1836, and in other scientific journals, is the same as that written for insertion in the Proceedings of the Association. From that document, and from a written explanation of their views, which I obtained from the authors, the present observations are deduced.

traces of the upper Silurian strata, nor of the old red sandstone, nor even of the mountain limestone in its ordinary aspect. On the contrary, the next group met with in ascending order, is a culmiferous series, the base of which distinctly reposes upon the abovementioned ancient rocks. This culmiferous deposit, far from appearing as a mere band, or at detached points, occupies about one third of the large county of Devon, and a considerable adjacent part of Cornwall; its southern boundary ranging from Exeter on the east, by Launceston, to St. Gennis in Cornwall on the west; its northern frontier running by Barnstaple and South Moulton to near Wellington in Somersetshire. These culmiferous beds are shown to contain thick beds of limestone, entirely dissimilar in structure and fossil contents from any limestones of the underlying "grauwacke," in which they had previously been merged. The culm measures consist of grit, sandstone, shale and limestone; and these rocks, it is said, are never affected by a slaty cleavage like the lower Silurian and Cambrian rocks on which they rest. From this character, as well as from their prevailing mineralogical structure and imbedded fossil plants, the authors regard the culmiferous formation of Devon as perfectly identical in age with other coal-fields, and as more particularly analogous to the culm-bearing strata of Pembrokeshire; a part of which also once passed for "grauwacke," but Mr. Murchison has recently shown that it belongs to the South Welsh coal-field, which is known by all geologists to rest upon mountain limestone.

Thus referred to the age of our ordinary coal, these strata of North Devon are further proved to lie in a great trough, their southern edges being turned up against the granite of Dartmoor, where they acquire, in contact with the granite, when traversed by elvan dykes, many characters of the metamorphic rocks, or those commonly termed primary. The phænomena of interference and alteration at the junction are such as to give a comparatively modern date for the eruption of the Dartmoor granite, and to explain why so much difficulty and ambiguity has prevailed in determining the age of some of the altered culm beds.

Among other points which this survey of Professor Sedgwick and Mr. Murchison has settled, so far as Devon is concerned, is one of the highest theoretical interest, and on which for more than two

years the Society has been anxiously desiring more accurate information; I allude to the true stratigraphical position of certain shales near Bideford in North Devon, containing fossil plants of the same species as those which are found abundantly in the coal. I may first remind you that a discussion had previously arisen respecting the alleged discovery by Mr. Weaver of anthracite, with the usual carboniferous plants, in the greywacke or transition rocks of Ireland*. Notwithstanding the value justly attached to the opinion of so experienced and long-practised an observer, your Council hesitated to print his statement, and requested him to reexamine the ground. At the same time Mr. Griffiths, to whom we are looking for the publication of a Geological Map of Ireland, had come to a different conclusion, and Mr. Weaver having been induced to repeat his observations, became convinced that he was in error, and has since studiously availed himself of every opportunity of announcing this change in his views.

You are aware that as yet in the British islands, scarcely any vegetable impressions have been met with in rocks more ancient than the carboniferous strata above the old red sandstone, so that we know not what species of plants belong to the greywacke or transition group. We can only presume from analogy that since the shells, corals, and other organic remains of that ancient group differ from those found above the old red sandstone, the plants also, if ever discovered, will differ as greatly. Considerable surprise was therefore excited when, during the Presidentship of my predecessor in this chair, a letter was read, addressed to him from Mr. De la Beche, stating that he had found, near Bideford in North Devon, many well known coal plants in the lower greywacke, or far down in the transition series†. Such of the plants as were determinable had been identified by Professor Lindley with species characteristic of the true coal measures, and which had never been found elsewhere below the coal. The anomaly, therefore, in the supposed position of these fossils was so great, that between the ordinary geological site of such remains, and that in which they were here inferred to present themselves, there would be interposed if the series were complete the whole of the old red sandstone, and at least the two upper forma-

* Proceedings Geol. Soc., vol. i. p. 231.

† Proceedings Geol. Soc., vol. ii. p. 106.

tions of the Silurian system. When this point was considered, I expressed to the Society my opinion, in common with Mr. Murchison, as to the insufficiency of the proofs relied on by our Foreign Secretary, and we felt that we had a right to call for more conclusive evidence. The simple fact of shales having been found charged with true coal plants, raised so strong a presumption in favour of their belonging to the regular carboniferous series, that the burthen of proof rested with him who wished to assign to them either a higher or lower position. Our scepticism was regarded by Mr. Greenough as implying too marked a bias for a preconceived theory, and this he afterwards hinted in his Anniversary Address*. I may affirm, however, that in the first place it implied on my part no distrust of Mr. De la Beche's skill or experience in geological surveying, and that had Professor Sedgwick and Mr. Murchison advanced a similar opinion on analogous proofs, I should equally have withheld my assent. Suppose, for example, they had announced to us that they had found fossil fruits and leaves identical with those of Sheppey in strata of the age of the white chalk with flints. I should have demanded from them, in corroboration, the most clear, unequivocal, and overwhelming evidence. If it were a region of disturbed and vertical strata, I should expect them first to have resorted in vain to every hypothesis of inverted stratification with a view of explaining away such an exception to the general rule.

I might perhaps be told that we are unacquainted with the flora of the upper cretaceous period, and I admit that we are as ignorant of it as of that which belonged to the transition period, but when we consider the contrast of the shells and other fossils of the chalk and London clay, we naturally anticipate that if plants are ever found of the precise age of our chalk with flints, they will not prove to be of the same species as those of the Sheppey clay. There is a like presumption from analogy against the conclusion that the same vegetation continued to flourish on the earth from the period of the lower greywacke to that of the coal, because we know that in the course of the intervening epochs the testacea, zoophytes, fish, and other classes of organic beings were several times changed.

In regard to the proofs relied on by Mr. De la Beche, I should observe that he never attempted to show that the plant-bearing

* Proceedings Geol. Soc., vol. ii. p. 164.

shales at Bideford were interstratified with rocks charged with shells or other fossils known to belong to rocks older than the old red sandstone.

Since writing the above sketch of the different views recently published of the structure of Devonshire, I have received a letter from Mr. De la Beche, from which I am happy to learn, that it is his intention before concluding his report on the Ordnance Map of Devon, to reexamine Devonshire. He is far, he says, from pretending that his first views were perfect, and if he finds reason to modify any of them, he shall not hesitate to announce the change of opinion. In the mean time he no longer contends that the culmiferous strata are referable to the lower greywacke, and considers the point of difference to lie within a narrower compass, namely, whether the culm beds are to be considered as upper greywacke or coal. This question, on which he is not yet satisfied, evidently appears to him of much less theoretical importance than, I confess, it does to me. It is fair, however, that I should state the arguments which influence his mind. If the plants, he says, found at Bideford in the culmiferous series should belong to strata more ancient than the old red sandstone the fact would not stand alone, for he has lately received a letter from M. Elie de Beaumont, detailing analogous phenomena in Brittany. It is stated that the greywacke there closely corresponds in general character with that of Devon, the upper part like the Devonian series containing anthracite. With this anthracite or culm are found at Montrelais, Chatelaison, and other places, fossil plants, the greater part of which are identical with those in the coal measures; but there are others which have not hitherto been detected in the latter rock. Patches of true coal measures rest in unconformable position upon these upper greywacke beds of Brittany. Now I regret that I have not seen any printed account of the geology of this part of France; for until we learn whether the plants in question are associated with true Silurian fossils, the testimony is quite incomplete. We know not, for instance, whether the plant-bearing series in question is old red sandstone or a Silurian formation, or whether it is a lower part of the true carboniferous system of which the strata had been disturbed before a higher portion was superimposed.

Similar remarks hold in regard to the observations made by

M. Virlet in the Dictionnaire d'Hist. Naturelle, where in his late article "De l'Origine des Combustibles Minéraux," he speaks of certain carboniferous deposits of Ireland, (those alluded to by Mr. Weaver before mentioned,) as well as others examined by M. Voltz in the Black Forest, also the culm beds of Brittany, and those of the department of La Sarthe, as all belonging in age to the newest transition formations, "*terrains de transition les plus récens.*"

Mr. De la Beche alludes to another discovery of coal plants implying as great an anomaly as that which he had imagined to occur in Devonshire, and by which he was himself once led into error during an Alpine excursion, about eighteen years since, when he met with coal plants in the schists of the Col de Balme, in Switzerland. He then inferred that the beds belonged to the true coal measures, but M. Elie de Beaumont afterwards proved them to be lias; that is say, he identified them with other rocks not far distant in the Alps, which were shown to be lias by containing Belemnites and other fossils. Mr. De la Beche was at first sceptical on the point, but after revisiting the Alps, he came round to the same opinion. Having therefore been in one instance misled by relying on the fossil vegetables of the coal as affording a good chronological test, he naturally attached but small value to the same testimony as a criterion of the age of another set of rocks in Devonshire. Now you will easily understand that a geologist, who is once persuaded that the same plants flourished in European latitudes from the period of the true coal to that of the lias, will be ready to concede without difficulty the probable existence of the same plants at an era long antecedent to the coal. We know that between the deposition of the coal and the lias there were successive revolutions in the races of animals which inhabited the waters, the zoophytes, mollusca, fish, and, as far as we know them, the reptiles having been changed again and again; so that the fossils of the mountain limestone differ from those of the magnesian limestone or zechstein, these again from the organic remains of the muschelkalk, and these last from those of the lias. If we are to believe that the same plants survived on the land, while such fluctuations in animal life occurred in the waters, why should we not imagine the longevity of the same species to have been still greater, so that they began to exist even before the deposition of the old red sandstone? But let

me remind you that botanists have been led to very different conclusions respecting the laws governing the distribution of fossil vegetables from the study of undisturbed districts. You are not ignorant that the strata of the Alps are involved in extreme confusion and complexity, mountain masses having been completely overturned and twisted, so that the same set of strata have been found at the top and bottom of the same section separated by several thousand feet of beds belonging to an older formation. So obscure is the order of position in Alpine geology, that the cretaceous and greensand series have been classed by experienced geologists as more ancient than the oolite, under which, in point of fact, they occasionally lie.

Professor Studer, in his work on the Bernese Highlands, after years of personal investigation, has published a map in which he has given a coloured ground plan without venturing to commit himself by sections, or a table of the regular order of superposition.

After devoting a summer to the investigation of the same portion of Switzerland, with the advantage of Mr. Studer's map and work, I was unable to satisfy myself that I had found a key to the classification or superposition of the formations, so enormous is the scale on which they have been deranged. I collected fossil plants on the Col de Balme, but I have not examined the precise localities further to the west appealed to by M. de Beaumont. I am far, therefore, from denying his facts or inferences, hoping at some future period more carefully to inquire into the evidence on the spot. No one, I am aware, is more desirous that others should visit the southern Alps and verify or criticise his facts than M. de Beaumont. Meanwhile I am reminded of an expression of our mutual friend M. von Buch. When I related to him some geological phænomena which surprised him; "I believe it," he said, "because you have seen it, but had I only seen it myself, I should not have believed it."

But to conclude, and to recall your attention to the structure of Devonshire, you will perceive that Mr. Murchison and Professor Sedgwick have endeavoured, and I think successfully, to work a great reform in the classification of the ancient rocks of that country, by applying to them the arrangement which they had previously made for the deposits termed by them Cambrian and Lower Silurian in Wales and the adjoining parts of England. According

to their survey and sections the coal plants of Bideford, so far from constituting any anomaly, so far from affording any objection to the doctrine that particular species of fossil plants are good tests of the relative age of rocks, do in reality from the place which they occupy, confirm that doctrine; for the culmiferous rocks distinctly overlie the so-called grauwacké, and are not referable to any of the well defined and normal types, which compose the old Red Sandstone and Silurian System.

I shall now pass on to the consideration of other memoirs on English Geology. The limestone which the Germans call muschelkalk, and the numerous fossils which are peculiar to it, have not yet been detected in England in any part of that great series of beds which intervene between the lias and the coal. In those parts of Germany where it occurs, it divides the beds of red marl and sandstone which occupy that great interval into two divisions, the upper of which is called keuper, and the lower bunter sandstein. In the absence of the muschelkalk in this country, it has been impossible for us to separate our new red sandstone into two well defined masses; but Dr. Buckland considers that certain portions of the upper beds in Warwickshire and elsewhere may be identified with the keuper by their mineral character, and near Warwick by the remains of a Saurian, which he believes to be of the genus Phytosaurus, a genus characteristic of the keuper of Wirtemberg.

An examination in the South-east of England of the strata usually termed plastic clay, has led Mr. John Morris to offer several new, and as they appear to me, judicious suggestions in regard to the classification of these beds. It is well known that wherever the tertiary strata are seen in immediate contact with the chalk, they consist of alternations of sand, clay, and pebbles, and in some few places a calcareous rock,—all these varying greatly in their thickness, and in their order of succession in different places. Mr. Morris divides those of Woolwich into two parts, and states that the upper is characterized by a mixture of marine and freshwater shells, the freshwater genera being Cyrena, Neritina, Melanopsis, and Planorbis. The lower division contains exclusively marine shells. The author refers this intermixture to the influx of a river into the sea, in which the London clay was formed. Mr. Morris considers the Bognor strata, which rest immediately

upon chalk, as the equivalents of the lower Woolwich deposit, observing that the shells agree with those of the London clay. These remarks seem to confirm the conclusion to which he had been previously led by the grand section at Alum Bay in the Isle of Wight, namely, that the beds usually styled plastic and London clays belong to one zoological period.

MINERAL VEINS.

Your attention has been called to the origin of mineral veins by Mr. Fox, who has endeavoured to explain why so large a proportion of the metalliferous veins in England and other parts of the world should have an east and west direction. He supposes fissures filled with water, containing sulphurets and muriates of copper, tin, iron, and zinc in solution, through which currents of voltaic electricity are transmitted. The metals separated from their solvents by this action are deposited in the veins, and most abundantly in veins running at right angles to the direction of the earth's magnetism; for as the magnetic currents of the earth pass from north to south, they cause those of electricity to move east and west, although considerable deviations from this direction must be occasioned in the course of geological epochs by variations in the magnetic meridian.

Since Mr. Fox first ascertained the existence of electric currents in some of the metalliferous veins in Cornwall*, Mr. Henwood has made many experiments on the same subject, together with observations on the distribution of metallic and earthy minerals in veins. He considers the results obtained by him to be in a great degree opposed to the theory of Mr. Fox†.

Mr. Fox conceives the fissures in which metalliferous substances occur, to have been at first small and narrow, and to have increased gradually in their dimensions. This doctrine has also been propounded in a work with which you are probably familiar, and from which I have derived much instruction, I mean M. Fournet's Essay on Metalliferous Deposits. This Essay was originally included in the 3rd

* Phil. Trans. 1830, p. 399.

† See Mining Journal, Supplement 9. p. 34, December 1836, and Annals of Electricity, No. 2. vol. i. on Electric Currents, &c. by W. T. Henwood Esq.

volume of M. Burat's continuation of D'Aubuisson's Treatise on Geology (1835), but it is now published separately, and gives the clearest general view which I have seen of the application of geological theories to phænomena observed in mining. It is written by one who has acquired much practical knowledge as a miner, and who is well versed in chemistry and mineralogy*.

Werner, when he published his justly celebrated Essay on Mineral Veins, had come to the conclusion that the same rent, after being wholly or partially filled, has sometimes been reopened; and M. Fournet has endeavoured more fully to explain the successive dilatation of the same veins at distinct periods. He has given examples in mines worked under his direction in Auvergne, in which the sulphurets of iron, copper, lead, and zinc, besides quartz, barytes, and other minerals, seem evidently to have been introduced at different periods by chemical action accompanied by new fractures and dislocations of the rocks, and the widening of preexisting fissures†.

You will find in M. Fournet's treatise a copious analysis of a great variety of books on mining, besides a detail of facts which have fallen under his own observation. He has described first those veins which are decidedly connected with rents produced in rocks by mechanical movements, and which are supposed to have been chiefly filled from below by sublimation, more or less obviously connected with volcanic action. He afterwards passes on to the consideration of those masses which have been called stockwerks by the Germans, which are imagined by some to have their origin in the contraction of granite, porphyry, and other rocks as they cooled, numerous rents being then formed, in which metallic particles were concentrated. In treating the subject in this order the author appears to me to have followed the most philosophical course, beginning with cases of undoubted rents of mechanical origin filled with minerals and metals introduced by sublimation, and then carrying with him as far as possible the light derived from these sources to dissipate a part of the obscurity in which all theories respecting the nature of Plutonic rocks and their minerals must, I fear, be for ever involved. Much will still remain unexplained; but

* Etudes sur les Dépots Métallifères, par M. I. Fournet.

† See "Etudes," &c. Section 3.

those who proceed in an opposite direction often throw doubt and confusion upon the simplest phænomena, as has sometimes happened in an analogous case, when geologists have begun with the examination of granite and granite veins, and have then endeavoured to apply the ideas derived from this study to the trap rocks and volcanic dykes.

Among the most interesting conclusions deduced by M. Fournet from his examination of the mining districts of Europe, I may mention the modern periods at which the precious metals appear to have entered into some veins: thus, to select a single example, some veins of silver of Joachimsthal in Bohemia are proved to have originated in the tertiary period*.

FOREIGN GEOLOGY.

Among the researches into the geology of foreign countries in which our members have been recently engaged, I have great pleasure in alluding to the labours of Mr. H. E. Strickland and Mr. Hamilton in Asia Minor. These gentlemen first examined the neighbourhood of Constantinople, and found on both sides of the Thracian Bosphorus an ancient group of fossiliferous strata, consisting of schist, sandstone, and limestone. From the character of the fossils it is inferred that these rocks may probably be the equivalents of the upper transition or Silurian strata of England. The shells belong to the brachiopodous genera Spirifer, Producta, and Terebratula, with which the remains of corals and Crinoidea were associated, and fragments of a Trilobite.

The rarity of any fossiliferous deposits of higher antiquity than the old red sandstone in any of the countries bordering the Mediterranean, or indeed to the south of the Alps and Pyrenees, lends considerable interest to this observation. In their way through France, our travellers examined the well known region of extinct volcanos in Auvergne, and afterwards found a counterpart to it in the Catacecaumene, a district in Asia known by that name in the time of Strabo, from its burnt and arid appearance. Some of the volcanos in Asia are of very modern appearance, although no notice of their eruptions falls within the limits of history or tradition. The vol-

* See "Etudes," &c. Section 2.

canic hills rise partly through lacustrine limestone in the Valley of the Hermus, and partly cover the slope of the schistose hills which bound it to the south. There are about thirty older cones, worn by time, and of which the craters are effaced or only marked by a slight depression; and three newer cones, which preserve their characters unaltered, the craters being perfectly defined and the streams of lava still black, rugged, and barren. Here, as in the country of corresponding structure in France, we find streams of lava following the course of existing valleys, and yet frequently cut through by rivers. We find also a tertiary freshwater formation, sometimes resembling chalk with flints, like that of Aurillac in France, and forming detached hills capped with basalt, while more modern lavas have flowed at the base of the same hills. The extent of this analogy will be best appreciated by those who compare Mr. Strickland's drawings with Mr. Poulett Scrope's masterly illustrations of the French volcanic region.

The countries watered by the rivers Meander and Cayster are described as having a simple geological structure. There are granitic rocks, with saccharine marble, there are also hippurite limestone and schist, and tertiary deposits unconformable to these, besides igneous rocks of various ages. The tertiary formations are chiefly lacustrine, and occur in nearly every large valley. They are composed of horizontal beds of calcareous marl and white limestone, in which are layers and nodules of flint; they also consist of sandstone, sand, and gravel.

The only representative of the secondary rocks of Europe is termed by Mr. Strickland "hippurite limestone", which appears to be very sterile in fossils. In this respect and in its other characters it agrees with that great calcareous formation described by MM. Boblaye and Virlet in their splendid work on the Geology of the Morea*. According to these French geologists, three quarters of the Peloponnesus are occupied by a compact limestone several thousand feet thick, in which they could discover scarcely any organic remains, except a few hippurites and nummulites, but which is supposed to be the equivalent of our chalk and oolites. Nothing,

* Paris, 1833, in folio. It is to be regretted that this work cannot be procured separately from other folios containing the scientific information collected during the French expedition to the Morea.

they say, can be more monotonous in character than this calcareous mass in the South of Europe, which appears to represent the larger part of our upper secondary formations of the North, where the rocks are so varied in lithological aspect and so distinguishable from each other by their well preserved fossils.

Ancient fossiliferous strata resembling those of the neighbourhood of Constantinople are said to be largely developed in the Balkan, a mountain chain of which we may soon expect to receive information from the pen of M. Ami Boué. That indefatigable geologist has already explored a large part of Servia, a country of whose physical and moral condition we are perhaps more ignorant than of any other in Europe, and he is rapidly extending his survey over various parts of the Turkish empire, to the examination of which he proposes to devote several years. Meanwhile our late Secretary, Mr. Hamilton, is continuing, with great zeal, his investigation of the borders of the Black Sea and other parts of Asiatic Turkey.

In a paper on the structure of part of the Cotentin near Cherbourg, the Rev. W. B. Clarke describes that country as consisting of hills or ridges of quartz rock alternating with valleys of slate occasionally associated with syenite and greenstone, which appear to be of posterior origin. A curious fact is mentioned: the quartz rock splits naturally into irregular masses, which have, nevertheless, some angles of fixed dimensions, namely, 103°, 64°, and 83°. Fragments of a green variety of schist exhibit the same angles under the same circumstances of position, proving that similar causes had acted on the two formations *en masse*, the same sets of joints, lines of stratification, and cleavage being found in both. Besides these facts, which are illustrated by diagrams, the author mentions others calculated to throw light on the cleavage and jointed structure of rocks.

PROOFS OF MODERN ELEVATION AND SUBSIDENCE.

Under this head I shall first consider several notices of beds of gravel, sand, clay, and marl, containing recent marine shells, which have been observed in various parts of Great Britain, a subject very frequently brought before our notice of late years. Deposits of this kind have been found by Dr. Scouler in the vicinity of Dublin, where they rise to the height of 80, and in some places of even 200

feet above the level of the sea. Besides marine shells of existing species, he has ascertained that some of the lower beds of this formation contain bones of the extinct Irish elk, by which we learn that this quadruped, although belonging to a comparatively modern period, and found in peat-mosses, had nevertheless begun to inhabit this part of the world at a period anterior to some of the last changes in the position of land and sea, changes which are proved by the upraised shelly beds just alluded to. Now Professor Nilsson of Lund in Sweden, although ignorant of these facts, had remarked to me that some great alteration must have occurred in the shape and extent of dry land and sea in Great Britain and the surrounding parts subsequently to the time when the Irish elk existed, otherwise so many entire skeletons of so large an herbivorous quadruped as the *Cervus megaceros*, would not have been found in so small an island as the Isle of Man. That island may at no remote geological period have been united to the main land, and may have since been separated from it by subsidences, on a scale equal to the elevations of which there is such clear evidence in Ireland and elsewhere.

Changes in the relative level of land and water, in the estuary of the Clyde, are indicated by facts described in another paper by Mr. Smith of Jordan Hill, near Glasgow. Superficial deposits, in which a great number of marine shells of recent species are imbedded, are found on the banks of the Clyde below Glasgow, at the height of 30 or 40 feet above the sea. I had myself an opportunity of verifying during the last summer several of these observations of Mr. Smith, and found equally clear proofs that the Island of Arran had participated in the upward movement, so that a circle of inland cliffs may be traced all round that island, between the base of which and the present high-water mark a raised beach occurs, and in some places beds of marine marls, formed of recent shells, as in the bay of Lamlash. Mr. Smith has also traced sea-worn terraces on each side of the Clyde below Dumbarton and between the Cloch Lighthouse and Largs.

We are indebted to Sir Philip Egerton for some new details respecting the shelly gravel of Cheshire, of which he had previously treated; and to Mr. Murchison and Professor Sedgwick for a joint-paper on "a raised beach in Barnstaple Bay on the north-west coast of Devonshire." This beach puts on for several miles where it is best exposed, the form of a horizontal under terrace resting upon an

indented and irregular surface of the older formations. It presents a cliff towards the sea, in which beds of calcareous grit, sandstone, and shingle are seen perfectly stratified. The bottom of the deposit is chiefly composed of indurated shingles resting on the ledges of the older rocks, and filling up their inequalities. Through the whole cliff, but especially in the indurated grits, shells are abundantly dispersed, identical in species with those now living on the coast, and well preserved, though sometimes waterworn.

The authors point out that these beds cannot have been formed by accumulations of blown sand. They demonstrate an elevation of the coast during the modern period; and there are phænomena both on the north and south coasts of Devonshire and Cornwall, which afford proofs of modern changes in the level of the land, both of upheaval and depression. The raised beach of Hope's Nose, correctly described by Mr. Austen, is the most striking instance in South Devon.

The quantity of rise of land in the modern period is from ten to forty feet in South Devon and Cornwall, nearly seventy feet in North Devon, while in Lancashire, Cheshire, and Shropshire there are marine deposits with recent shells at the height of from 300 to 500 feet above the sea.

It is natural to inquire what changes the surface of the dry land in England may have undergone during the occurrence of such upward and downward movements. Perhaps some observations lately made by Mr. Bowerbank in the south of the Isle of Wight may elucidate this point. He has given us an account of a bed of chalky detritus, containing recent land shells, at Gore Cliff. This bed is ten feet thick, and rests immediately upon chalk marl. Many of the shells, which are plentifully scattered through it, retain their colour. As the deposit ranges to the foot of St. Catherine's Down, it is possible that the waste and denudation of that chalk hill may have supplied the materials. I have lately seen similar detritus resting on the chalk with flints, and arranged in numerous thin layers in the section exposed in cutting the railroad at Winchester, where a black layer of peaty earth and carbonized wood intersects thin layers of white chalk rubble, from twenty to thirty feet thick. Such appearances are, in fact, very general in chalk districts; a bed of flints not waterworn occurring on the highest

downs, while fragmentary chalk, often inclosing land shells, occurs on their slopes and at lower levels. Violent rains have been known even of late years to tear off the turfy covering from certain points near Lewes, and to wash away flints and chalky mud, and leave them in the hollow combs or flanks of the hills. This action of the elements would be most powerful at periods when the chalk first emerged from the sea, or whenever it assumed in the course of subterranean disturbances a new position or physical outline.

We must, I think, infer from the occurrence of certain recent marine shells and shingle in the bottom of what has been termed the elephant-bed at Brighton, that the chalk in the South-east of England has undergone some movements of a modern date, the land having subsided there to the depth of fifty or sixty feet, and having been subsequently raised up again to a level somewhat higher than its original position*.

If it should appear upon careful research that the land shells found in terrestrial alluviums covering the chalk are almost universally of recent species, I should not conclude that the emergence of the chalk hills from the sea had generally occurred at a very modern period, but merely that these hills had been modified in shape in recent times, and that during that modification alluviums of older date had been washed away, or the land shells which they may once have contained have decomposed and disappeared. In regard to the great numbers of these shells preserved throughout the bed at Gore Cliff, and in many other places even at greater depths, it will not seem surprising to those who have observed the number of dead land shells which are strewed over the surface of the chalk downs, or lie concealed in the green turf in numbers almost as countless as the blades of grass. If the slightest wash of water should pass over such a soil, it must float off myriads of these shells, and they would immediately be involved in that white cream-coloured mud which descends from wasting hills of chalk after heavy rains. Land shells so buried may retain their colour for indefinite periods, as is shown by the state of species in the loess of the Rhine, and even in tertiary strata of much higher antiquity.

While a variety of geological monuments are annually discovered

* See Principles of Geology, 4th edit., vol. iv. p. 274.

which attest modern alterations in the level of the land, it is important to remark that new testimony is also daily obtained of the rising and sinking of land in our own times. I discussed at some length, in my last Anniversary Address, the evidence for and against the upheaval of the coast of Chili during the earthquake of 1822, a controverted point to which our attention has lately been again recalled. I may remark, however, that since we have ascertained the fact of a rise of three, five, and even ten feet in parts of the same country in 1835, so distinctly attested by Captain Fitzroy, all doubts entertained as to the permanent effects of a preceding convulsion are comparatively of small interest. Don Mariano Rivero dissents from the opinion that a change of level occurred at Valparaiso in 1822, and Colonel Walpole, after seeing the ground and conversing with persons who were on the spot in 1822, and who still reside there, also considers the statement of a rise to have been inaccurate. On the other hand Mr. Caldcleugh, who was formerly sceptical on the same point, has now come round to the opinion of Mrs. Callcott (Maria Graham), and believes that an elevation of land did take place.

Mr. Darwin, whose opportunities of investigation both in Chili and other parts of South America have been so extensive, thinks it quite certain that the land was upheaved two or three feet during the earthquake of 1822, and he met with none of the inhabitants who doubted the change of level. He states that the rise of land, even in the bay of Valparaiso, was far from being uniform, for a part of a fort not formerly visible from a certain spot has, subsequently to the earthquake, fallen within the line of vision. The most unequivocal proof of a recent rise is drawn from the acorn-shells, *Balanidæ*, found adhering to the rock above the reach of the highest tides. These were observed by Mr. Darwin sixty miles south of Valparaiso, and at Quintero, a few miles to the north of it; but his friend Mr. Alison detected them on a projecting point of rock at Valparaiso itself. The attached shells were there seen at the height of fourteen feet above high-water mark, and were only exposed upon the removal of the dung of birds, by which they would have been concealed from ordinary observation. In Mr. Darwin's paper you will find many other facts elucidating the rise of land at Valparaiso, and he has also treated of the general question of the

elevation of the whole coast of the Pacific from Peru to Terra del Fuego. Beds of shells were traced by him at various heights above the sea, some a few yards, others 500 or even 1300 feet high, the shells being in a more advanced state of decomposition in proportion to their elevation. Mr. Darwin also shows that parallel terraces such as those of Coquimbo, described by Captain Basil Hall and others, which rise to the height of 300 feet and more, are of marine origin, being sometimes covered with sea-shells, and they indicate successive elevations. There are also grounds for believing that the modern upheaval of land has proceeded not only by sudden starts during convulsions of the earth, but also by insensible degrees in the intervals between earthquakes, as is now admitted to be the case in parts of Norway and Sweden.

This gradual and insensible rising is supposed to affect, not only the region of the Andes, but also the opposite or eastern coast of South America, where earthquakes are never experienced: for the Pampas of Buenos Ayres bear marks of having risen to their present height during a comparatively modern period, while the coast line of the Pacific, or the region of earthquakes and volcanic eruptions, has been the theatre of more violent movements.

It is curious to reflect that if in one portion of a large area of the earth's surface a rise of land takes place at the rate of a few inches in a century, as around Stockholm, while in another portion of the same area land is uplifted about a yard during an equal period, there will be caused, if sufficient time be allowed, a group or chain of lofty mountains in one place, and in the other a low country like the Pampas of South America.

Evidence of a sinking down of land, whether sudden or gradual, is usually more difficult to obtain than the signs of upheaval. I shall therefore mention some facts which have been lately communicated to me by Professor Nilsson, from which it appears that Scania, or the southernmost part of Sweden, has been slowly subsiding for several centuries, in the same manner as was lately shown to be the case with part of Greenland. In the first place there are no elevated beds of recent marine shells in Scania, like those near Stockholm and further to the north. Linnæus, with a view of ascertaining whether the waters of the Baltic were retiring from the Scanian shore, measured in 1749 the distance between the sea and a large stone

near Trelleborg. Now Mr. Nilsson informs me that this same stone is a hundred feet nearer the water's edge than it was in Linnæus's time, or eighty-seven years before. He also states that there is a submerged peat moss, consisting of land and freshwater plants, beneath the sea at a point to which no peat could have been drifted down by any river. But what is still more conclusive, it is found that in sea-port towns, all along the coast of Scania, there are streets below the high-water level of the Baltic, and in some cases below the level of the lowest tide. Thus when the wind is high at Malmö the water overflows one of the present streets, and some years ago some excavations showed an ancient street in the same place eight feet below, and it was then seen that there had evidently been an artificial raising of the ground, doubtless in consequence of that subsidence. There is also a street at Trelleborg and another at Skanör a few inches below high-water mark; and a street at Ystad is just on a level with the sea, at which it could not have been originally built. I trust that we shall soon receive more circumstantial details of these curious phænomena, which are the more interesting because it has been shown that the elevatory movement in Sweden diminishes in intensity as we proceed southward from the North Cape to Stockholm, from which it seems probable that after passing the line or axis of least movement, where the land is nearly stationary, a movement may be continued in an opposite direction, and thus cause the gradual sinking of Scania.

I cannot take leave of this subject without remarking that the occurrence in various parts of Ireland, Scotland, and England, of recent shells in stratified gravel, sand, and loam, confirm the opinion which I derived from an examination of part of Sweden, namely, that the formations usually called diluvial have not been produced by any violent flood or débacle, or transient passage of the sea over the land, but by a prolonged submersion of the land, the level of which has been greatly altered at periods very modern in our geological chronology. I now believe that by far the greatest part of the dispersion of transported matter has been due to the ordinary moving power of water, often assisted by ice, and cooperating with the alternate upheaval and depression of land. I do not mean wholly to deny that some sudden rushes of water and partial inundations of the sea have occurred, but we are enabled

to dispense with their agency more and more in proportion as our knowledge increases.

ORGANIC REMAINS.

Gentlemen, you have been already informed that the Council have this year awarded two Wollaston Medals, one to Captain Proby Cautley of the Bengal Artillery, and the other to Dr. Hugh Falconer, Superintendent of the Botanic Garden at Saharunpore, for their researches in the geology of India, and more particularly their discovery of many fossil remains of extinct quadrupeds at the southern foot of the Himalaya mountains. At our last Anniversary I took occasion to acknowledge a magnificent present, consisting of duplicates of these fossils, which the Society had received from Captain Cautley, and since that time other donations of great value have been transmitted by him to our museum. These Indian fossil bones belong to extinct species of herbivorous and carnivorous mammalia, and to reptiles of the genera crocodile, gavial, emys, and trionyx, and to several species of fish, with which shells of fresh-water genera are associated, the whole being entombed in a formation of sandstone, conglomerate, marl, and clay, in inclined stratification, composing a range of hills called the Siwâlik, between the rivers Sutledge and Ganges. These hills rise to the height of from 500 to 1000 feet above the adjacent plains, some of the loftiest peaks being 3000 feet above the level of the sea.

When Captain Cautley and Dr. Falconer first discovered these remarkable remains their curiosity was awakened, and they felt convinced of their great scientific value; but they were not versed in fossil osteology, and being stationed on the remote confines of our Indian possessions, they were far distant from any living authorities or books on comparative anatomy to which they could refer. The manner in which they overcame these disadvantages, and the enthusiasm with which they continued for years to prosecute their researches when thus isolated from the scientific world is truly admirable. Dr. Royle has permitted me to read a part of their correspondence with him when they were exploring the Siwalik mountains, and I can bear witness to their extraordinary energy and perseverance. From time to time they earnestly requested that Cuvier's works on osteology might be sent out to them, and expressed their

disappointment when, from various accidents, these volumes failed to arrive. The delay perhaps was fortunate, for being thrown entirely upon their own resources, they soon found a museum of comparative anatomy in the surrounding plains, hills, and jungles, where they slew the wild tigers, buffalos, antelopes, and other Indian quadrupeds, of which they preserved the skeletons, besides obtaining specimens of all the genera of reptiles which inhabited that region. They were compelled to see and think for themselves while comparing and discriminating the different recent and fossil bones, and reasoning on the laws of comparative osteology, till at length they were fully prepared to appreciate the lessons which they were taught by the works of Cuvier. In the course of their labours they have ascertained the existence of the elephant, mastodon, rhinoceros, hippopotamus, ox, buffalo, elk, antelope, deer, and other herbivorous genera, besides several canine and feline carnivora. On some of these Dr. Falconer and Captain Cautley have each written separate and independent memoirs. Captain Cautley, for example, is the author of an article in the Journal of the Asiatic Society, in which he shows that two of the species of mastodon described by Mr. Clift are, in fact, one, the supposed difference in character having been drawn from the teeth of the young and adult of the same species. I ought to remind you that this same gentleman was the discoverer, in 1835, of the Indian Herculaneum or buried town near Behat, north of Seharunpore, which he found seventeen feet below the surface of the country when directing the excavation of the Doab Canal*.

But I ought more particularly to invite your attention to the joint paper by Dr. Falconer and Captain Cautley on the Sivatherium, a new and extraordinary species of mammalia, which they have minutely described and figured, offering at the same time many profound speculations on its probable anatomical relations. The characters of this genus are drawn from a head almost complete, found at first enveloped in a mass of hard stone, which had lain as a boulder in a water-course, but after much labour the covering of stone was successfully removed, and the huge head now stands out with its two horns in relief, the nasal bones being projected in a free arch, and the molars on both sides of the jaw being singularly

* Journ. of Asiatic Society, Nos. xxv. and xxix. 1834. Principles of Geology, 4th and subsequent editions. See Index, Behat.

perfect. This individual must have approached the elephant in size. The genus Sivatherium, say the authors, is the more interesting, as helping to fill up the important blank which has always intervened between the ruminant and pachydermatous quadrupeds; for it combines the teeth and horns of a ruminant, with the lip, face, and probably proboscis of a pachyderm. They also observe, that the extinct mammiferous genera of Cuvier were all confined to the Pachydermata, and no remarkable deviation from existing types had been noticed by him among fossil ruminants, whereas the sivatherium holds a perfectly isolated position, like the giraffe and the camels, being widely remote from any other type.

I have not space to enter upon the warm discussion which has arisen in France between MM. Blainville and Geoffroy St. Hilaire respecting the amount of analogy which exists between the Sivatherium and the Giraffe; but I observe with pleasure that in the course of that controversy those distinguished naturalists do justice to the zeal and talents displayed by our countrymen Captain Cautley and Dr. Falconer, and to the services which they have rendered to science.

While these discoveries were made on the banks of the tributaries of the Indus and the Ganges, Mr. Darwin was employed in collecting the bones of large extinct mammalia, near the banks of the Rio Plata, in the Pampas of Buenos Ayres and in Patagonia. Mr. Owen has enabled me to announce to you in a few words some of the most striking results which he has obtained from his examination of the specimens liberally presented by Mr. Darwin to the College of Surgeons, and of which casts will soon be made for our own and other public museums. In the first place, besides a cranium with teeth of the Megatherium, Mr. Darwin has brought home portions of another animal as large as an ox, and allied to the Megatherium. Fragments of its armour are preserved, as well as its jaws, femur, and other bones. There is also a third creature of the order Edentata, and belonging to this same family of Dasypodidæ, in the shape of a gigantic Armadillo, as large as a Tapir. Of the ruminant order there is also a no less remarkable representative in the remains of a gigantic Llama from the plains of Patagonia, which must have been as large as a camel and with a longer neck: and lastly, of the Rodentia there is the cranium of a huge animal of

the size of a rhinoceros, with some modification in the form of the skull resembling that in the Wombat.

These fossils, of which a description will shortly be given to the Society by Messrs. Clift and Owen, establish the fact that the peculiar type of organization which is now characteristic of the South American mammalia has been developed on that continent for a long period, sufficient at least to allow of the extinction of many large species of quadrupeds. The family of the armadillos is now exclusively confined to South America and here we have from the same country the Megatherium, and two other gigantic representatives of the same family. So in the Camelidæ, South America is the sole province where the genus Auchenia or Llama occurs in a living state, and now a much larger extinct species of Llama is discovered. Lastly, among the rodents, the largest in stature now living is the Capybara, which frequents the rivers and swamps of South America and is of the size of a hog. Mr. Darwin now brings home from the same continent the bones of a fossil rodent not inferior in dimensions to the rhinoceros.

These facts elucidate a general law previously deduced from the relations ascertained to exist between the recent and extinct quadrupeds of Australia; for you are aware that to the westward of Sydney on the Macquarie River, the bones of a large fossil kangaroo and other lost marsupial species have been met with in the ossiferous breccias of caves and fissures.

A cavern has lately been examined at Yealm Bridge, six miles south-east from Plymouth, by one of our members, Lieut. Col. Mudge, R.E., from whose account it appears that the bones of hyænas are very numerous there. They are associated with those of the elephant, rhinoceros, horse, and other animals usually found in caves. The number of fossil Carnivora, such as the hyæna, wolf, fox, and bear, which have now been met with in districts of cavernous limestone in Great Britain, is so great that we are the more struck with the rarity and general absence of such remains in surrounding and intervening districts, over which the same beasts of prey must have ranged. The Pachydermata, as the elephant, rhinoceros, and hippopotamus, are often discovered in ancient alluvial or fluviatile deposits; but had there been no caves and fissures we should scarcely have obtained any information respecting the existence of

lions, tigers, hyænas, and other beasts of prey which inhabited the country at the same period.

The remains of at least two distinct Saurian animals have been discovered by Dr. Riley and Mr. Samuel Stutchbury, in the dolomitic conglomerate of Durdham Down near Bristol. They are allied to the Iguana and Monitor, but the teeth, vertebræ, and other bones exhibit characters by which they are seen to be generically distinct from all existing reptiles. They are particularly deserving of your attention as occurring in the bottom of the magnesian limestone formation, the oldest strata in which the bones of reptiles have as yet been found in Great Britain. The most ancient examples of fossil reptiles known on the continent of Europe occur also in the zechstein of Germany, a formation of about the same age.

I alluded last year to a memoir of Sir Philip Egerton's, in which he pointed out some peculiarities in the structure of the cervical vertebræ of the Ichthyosaurus. He has now proved that in all the species of this genus there are three accessory bones, which he proposes to call, from their shape and position, subvertebral wedge bones. They are supplementary to the atlas, axis, and third vertebra of the neck, and seem to have escaped the observation of Cuvier and other osteologists.

Mr. Lewis Hunton has communicated to the Society an elaborate account of a section of the upper lias and marlstone in Yorkshire, showing that different beds in those formations are characterized by particular species of Ammonites and other Testacea, each species having a limited vertical range. His observations are valuable not only as illustrating the distribution of fossils on the coast near Whitby, but also as furnishing a point of comparison between that district and many others in Great Britain. Mr. W. C. Williamson of Manchester has had the same object in view in studying the fossils of the oolitic formations of the coast of Yorkshire, and informs us, as the result of his patient investigation, that although certain assemblages of fossils abound in particular subdivisions of the oolite, many species range from the lowermost to nearly the highest beds. This inference is confirmed when we compare the lists drawn up by Mr. Williamson, and those published by Professor Phillips and other competent authorities. Thus some of the shells of the inferior oolite, mentioned in Mr. Williamson's list (*Trigonia gibbosa*,

for example), occur also in the Portland-stone of Wiltshire; another, as *Ostrea Marshii*, is characteristic of the cornbrash in the same county; others pass downwards to the lias, as *Orbicula reflexa* and *Ammonites striatulus*. If you consult the tables of organic remains which Dr. Fitton has annexed to his excellent monograph on the strata below the chalk, just published in our Transactions, (2nd Series, vol. iv. part 2.) you will see that a considerable number of shells pass from the upper oolitic groups into the green-sand. We are not to conclude from these facts that certain sets of fossils may not serve as good chronological tests of geological periods, but we must be cautious not to attach too much importance to particular species, some of which may have a wider, others a more limited vertical range. The phænomena alluded to are strictly analogous to those with which we are familiar in the more modern deposits, where different tertiary formations contain some peculiar Testacea, together with others common to older or newer groups, or where shells of species now living in the sea are associated with others that are extinct.

An assemblage of fossil shells has been presented to our museum by Mr. J. Leigh and Mr. J. W. Binney, found at Collyhurst near Manchester, in red and variegated marls, which were referred by them at first to the upper division of the new red sandstone group; but Professors Sedgwick and Phillips consider them to be a red and variegated deposit, belonging to the magnesian limestone series. As these fossils are new and characteristic of a particular subdivision of the beds between the lias and coal, it is to be hoped that they will soon be described and figured.

The petrifaction of wood, and more especially its silicification, still continues to present obscure problems to the botanist and chemist. The first step towards their solution will probably be made by carefully examining vegetables in different stages of petrifaction; and with this view Mr. Stokes has procured several specimens of wood, partly mineralized and partly not. Among these is a piece found in an ancient Roman aqueduct in Westphalia, in which some portions are converted into spindle-shaped bodies consisting of carbonate of lime: while the rest of the wood remains in a comparatively unchanged state. The same author has pointed out cases both of siliceous and calcareous fossils,

where the lapidifying process must have commenced at a number of separate points, so as to produce spherical or fusiform petrifactions, independent of each other, in which the woody structure is apparent, while in the intervening spaces the wood has decayed, having after removal been replaced by mineral matter. In some petrifactions the most perishable, in others the most durable portions of plants are preserved, variations which doubtless depend on the time when the mineral matter was supplied. If introduced immediately on the first commencement of decomposition, then the most destructible parts are lapidified, while the more durable do not waste away till afterwards, when the supply has failed, and so never become petrified. The converse of these circumstances gives rise to exactly opposite results. As to the manner in which the minutest pores and fibres discoverable by the microscope, even the spiral vessels themselves can be turned into stone, or have their forms faithfully represented by inorganic matter, no satisfactory explanation has ever yet been offered. In considering, however, this question, you will do well to consult the important suggestion which a celebrated chemist, our late lamented Secretary, Dr. Turner, has thrown out on the application of chemistry to geology. He reminds us that whenever the decomposition of an organic body has begun, the elements into which it is resolved are set free in a state peculiarly adapting them to enter into new chemical combinations. They are in what is technically termed a nascent state, the constituent molecules being probably of extreme smallness and in a fluid or gaseous form, ready to obey the slightest impulse of chemical affinity, so that if the water percolating a stratum be charged with mineral ingredients, and come in contact with elements thus newly set free, a mutual action takes place, and new combinations result, in the course of which solid particles are precipitated so as to occupy the place left vacant by the decomposed organic matter. In a word, all the phænomena attendant on slow putrefaction must be studied whenever we attempt to reason on the conversion of fossil bodies into stone; and in regard to silicification, Dr. Turner has shown how great a quantity of silex is set free as often as felspar decomposes, and how abundantly siliceous matter may be imparted from this source alone to running water throughout the globe.

As I have mentioned the name of Dr. Turner, I cannot pass on

without an expression of sorrow for the untimely death of that amiable and distinguished philosopher. Mr. Whewell and Mr. Murchison alluded in most feeling terms this morning at the General Meeting to this melancholy event, which is too recent and too painful to myself and others to allow me now to dwell longer upon it.

Before quitting the subject of vegetable petrifactions, I ought to mention a memoir just published, by Mr. H. R. Göppert, Professor of Botany at Breslau, "On the various Conditions in which Fossil Plants are found, and on the Process of Lapidification*." He has instituted a series of most curious experiments, and his success in producing imitations of fossil petrifactions has been very remarkable. I have only space to allude to one or two examples. He placed recent ferns between soft layers of clay, dried these in the shade, and then slowly and gradually heated them, till they were red hot. The result was the production of so perfect a counterpart of fossil plants as might have deceived an experienced geologist. According to the different degrees of heat applied, the plants were obtained in a brown or perfectly carbonized condition, and sometimes, but more rarely, they were in a black shining state, adhering closely to the layer of clay. If the red heat was sustained until all the organic matter was burnt up, only an impression of the plant remained.

The same chemist steeped plants in a moderately strong solution of sulphate of iron, and left them immersed in it for several days until they were thoroughly soaked in the liquid. They were then dried and kept heated until they would no longer shrink in volume, and until every trace of organic matter had disappeared. On cooling them he found that the oxyd formed by this process had taken the form of the plants. Professor Göppert then took fine vertical slices of the Scotch fir, *Pinus sylvestris*, and treated them in the same way; and so well were they preserved, that, after heating, the dotted vessels so peculiar to this family of plants were distinctly visible. A variety of other experiments were made by steeping animal and vegetable substances in siliceous, calcareous, and metallic solutions, and all tended to prove that the mineralization of

* Poggendorff, Annalen der Physik und Chemie, vol. xxxviii. part 4. Leipsic, 1836.

organic bodies can be carried much further in a short time than had been previously supposed.

These experiments seem to open a new field of inquiry, and will, I trust, soon be repeated in this country. In endeavouring, however, to verify them, the greatest caution will be required, or we may easily be deceived. We must ascertain, for example, with certainty that every particle of animal or vegetable matter is driven off before we attempt to determine the full extent to which mineralization may have proceeded. Professor Göppert is doubtless aware that coniferous wood may be burnt and reduced to charcoal, and after having been kept for some time at a red heat, will continue to exhibit, on being cooled, the discs or reticulated structure to which he alludes. If, therefore, some small particles of carbon remain in the midst of the oxide of iron, such portions may retain traces of the vessels peculiar to coniferous wood; and an observer not on his guard, might infer that the same structure was preserved throughout the mass.

In my last address, I alluded to Mr. Lonsdale's detection of vast numbers of microscopic corallines and minute shells in the substance of the white chalk of various counties in England, where this rock had not been suspected of consisting of recognisable organic bodies. I cannot deny myself the pleasure of mentioning the still more singular and unexpected facts brought to light during the last year, by Professor Ehrenberg of Berlin, respecting the origin of tripoli. I need scarcely remind you, that tripoli is a rock of homogeneous appearance, very fragile and usually fissile, almost entirely formed of flint, and which was called polir-schiefer, or polishing slate, by Werner, being used in the arts for polishing stones or metals. There have been many speculations in regard to its origin, but it was a favourite theory of some geologists that it was a siliceous shale hardened by heat. The celebrated tripoli of Bilin in Bohemia consists of siliceous grains united together without any visible cement, and is so abundant that one stratum is no less than fourteen feet thick. After a minute examination of this as well as of the tripoli from Planitz in Saxony, and another variety from Santa Fiora in Tuscany, and one from the Isle of France, Ehrenberg found that the stone is wholly made up of millions of siliceous cases and skeletons of microscopic animalcules. It is probably known to you, that this distinguished physiologist has devoted many years to the ana-

tomical investigation of the infusoria, and has discovered that their internal structure is often very complicated, that they have a distinct muscular and nervous system, intestines, sexual organs of reproduction, and that some of them are provided with siliceous shells, or cases of pure silex. The forms of these durable shells are very marked and various, but constant in particular genera and species. They are almost inconceivably minute, yet they can be clearly discerned by the aid of a powerful microscope, and the fossil species preserved in tripoli are seen to exhibit in the family Bacillaria and some others the same divisions and transverse lines which characterize the shells of living infusoria.

In the Bohemian schist of Bilin, and in that of Planitz in Saxony, both of them tertiary deposits, the species are freshwater, and are all extinct. The tripoli of Cassel appears to be more modern, and the infusoria in that place, which are also freshwater, are some of them distinctly identical with living species, and others not. In the tripoli brought from the Isle of France, the cases or shells all belong to well-known recent marine species.

The flinty shells of which we are speaking although hard are very fragile, breaking like glass, are therefore admirably adapted when rubbed for wearing down into a fine powder fit for polishing the surface of metals. It is difficult to convey an idea of their extreme minuteness, but I may state that Ehrenberg estimates that in the Bilin tripoli there are 41,000 millions of individuals of the *Gaillonella distans* in every cubic inch of stone. At every stroke therefore of the polishing stone we crush to pieces several thousands if not myriads of perfect fossils.

Gentlemen,—Although I have already extended this Address beyond the usual limits, I cannot conclude without congratulating you on the appearance of Dr. Buckland's Bridgewater Treatise, a work in the execution of which the author has most skilfully combined several distinct objects. He has briefly explained the manner in which the materials of the earth's crust are arranged, and the evidence which that arrangement affords of contrivance, wisdom, and foresight. He has also given us a general view of the principal facts brought to light by the study of organic remains; thus contributing towards the filling up one of the greatest blanks which existed in the literature of our science, while at the same time he has pointed out the bearing of these phænomena on natural theology.

He has shown that geology affords one kind of testimony perfectly distinct from natural history of the adaptation of particular means and forces to the accomplishment of certain ends for which the habitable globe has been framed. These proofs are illustrated in the author's chapters on the origin and mechanism of springs, on the distribution of metallic and other minerals in the earth, and the position of coal in stratified rocks. In reference to these points it is demonstrated that some even of the most irregular forces have produced highly beneficial results, in modifying the subterranean economy of the globe. But I shall not dwell on this part of the Treatise, but pass on at once to that which constitutes the body of the work, and which relates to palæontology.

In considering this department, the number and variety of objects which offer themselves to the naturalist are so great, that the choice was truly embarrassing. Dr. Buckland has judiciously selected a few of the most striking examples from each of the great classes of organic remains, and when speaking of extinct animals, has explained the method by which the anatomist and physiologist have been able to restore the organization of the entire individual, by reasoning from the evidence afforded by a few bones or other relics preserved in a fossil state. He has described the parts of the living animal or plant most nearly analogous to those which are found buried in the earth, usually illustrating by figures the distinctness and at the same time the resemblance of the recent and extinct species, showing that all are parts of one great scheme, and that the lost species even supply links which are wanting in the existing chain of animal and vegetable creation.

It is impossible to read the account given of the Megatherium, and to contrast it with that drawn up by Cuvier of the same species, without being struck with the increased interest and instruction, and the vast accession of power derived from viewing the whole mechanism of the skeleton in constant relation to the final causes for which the different organs were contrived.

The chapter on saurian and other reptiles has afforded the Professor another beautiful field for exemplifying the infinite variety of mechanical contrivances and combinations of form and structure which the fossil representatives of that class exhibit.

The account also of the Cephalopodous Mollusca, so many thousands of which are scattered through the strata, and which until

very recently have presented so obscure a problem to the naturalist, is full of original observation. The history of the animals which formed the Belemnites, of which it appears that nearly one hundred species are now known, and the proofs adduced that they were provided with ink-bags like the cuttle-fish, the description also of the fossil pen-and-ink fish, or Loligo, and other sections of this part of the Treatise, carry our information respecting the family of naked Cephalopods much further than was ever attempted in any previous work. Nor should I omit to mention the exposition of an ingenious theory for the use of the siphuncle and air-chambers of the Ammonite, which, whether confirmed by future examination or not, becomes in the author's hands the means of conveying to the reader a clear and well-defined notion of the varied forms and complicated structure of these shells, and of awakening a lively desire to understand their singular organization.

I may also recall to your notice the just and striking manner in which certain physical inferences are drawn from the conformation of the eyes of extinct Crustacea, such as the Trilobite. The most delicate parts of these organs are sometimes found petrified in rocks of high antiquity, and it is justly observed, that such optical instruments give information regarding the condition of the ancient sea and ancient atmosphere, and the relations of both these media to light. The fluid in which these marine animals lived at remote periods must have been pure and transparent to allow the passage of light to organs of vision resembling those of living Crustaceans; and this train of reasoning naturally leads us still further, and to more important consequences, when we reflect on the general adoption of the undulatory theory of light, and the connexion between light, heat, electricity, and magnetism.

I have heard it objected, that the zoologist and botanist had already advanced such abundant proofs of design in the construction of living animals, and plants, that the auxiliary evidence of palæontology was useless, and that to appeal to fossils in support of the same views was to add weaker to stronger arguments. In the living animal, it is said, we can study its entire organization, observe its habits, see the manner in which it applies each organ, and so verify with certainty the ends for which any particular member was formed and fashioned. But in the case of the fossil, we

have first to infer the greater part of the organization from such parts as alone remain, and then further to infer from analogy the habits and functions discharged, and lastly the former conditions of existence of the creatures so restored. If then we occasionally fall into error when speculating on the use of the organs of living species, how much more easily may we be deceived in regard to the fossil!

In answering this objection, it cannot be denied that the data supplied by palæontology are less complete; but they are nevertheless abundantly sufficient to establish a very close analogy between extinct and recent species, so as to leave no doubt on the mind that the same harmony of parts and beauty of contrivance which we admire in the living creature has equally characterized the organic world at remote periods. If this be granted, it is enough; the geologist can then bring new and original arguments from fossil remains to bear on that part of natural theology which seeks to extend and exalt our conceptions of the intelligence, power, wisdom, and unity of design manifested in the creation.

It can now be shown that the configuration of the earth's surface has been remodelled again and again; mountain chains have been raised or sunk, valleys have been formed, again filled up, and then re-excavated, sea and land have changed places, yet throughout all these revolutions, and the consequent alterations of local and general climate, animal and vegetable life has been sustained. This appears to have been accomplished without violation of those laws now governing the organic creation, by which limits are assigned to the variability of species. There are no grounds for assuming that species had greater powers of accommodating themselves to new circumstances in ancient periods than now. The succession of living beings was continued by the introduction into the earth from time to time of new plants and animals. That each assemblage of new species was admirably adapted for successive states of the globe, may be confidently inferred from the fact of the myriads of fossil remains preserved in strata of all ages. Had it been otherwise, had they been less fitted for each new condition of things as it arose, they would not have increased and multiplied and endured for indefinite periods of time.

Astronomy had been unable to establish the plurality of habitable

worlds throughout space, however favourite a subject of conjecture and speculation; but geology, although it cannot prove that other planets are peopled with appropriate races of living beings, has demonstrated the truth of conclusions scarcely less wonderful, the existence on our own planet of many habitable surfaces, or worlds as they have been called, each distinct in time, and peopled with its peculiar races of aquatic and terrestrial beings.

Thus as we increase our knowledge of the inexhaustible variety displayed in living nature, and admire the infinite wisdom and power which it displays, our admiration is multiplied by the reflection that it is only the last of a great series of pre-existing creations of which we cannot estimate the number or limit in past time.

All geologists will agree with Dr. Buckland, that the most perfect unity of plan can be traced in the fossil world throughout all the modifications which it has undergone, and that we can carry back our researches distinctly to times antecedent to the existence of man. We can prove that man had a beginning, and that all the species now contemporary with man, and many others which preceded, had also a beginning; consequently the present state of the organic world has not gone on from all eternity as some philosophers had maintained.

But when conceding the truth of these propositions, I am prepared to contest another doctrine which the Professor advocates, namely, that by the aid of geological monuments we can trace back the history of our terraqueous system to times anterior to the first creation of organic beings. If it was reasonable that Hutton should in his time call in question the validity of such a doctrine, whether founded on the absence of organic remains in strata called primary or in granite, still more are we bound, after the numerous facts brought to light by modern geology, to regard the opinion as more than questionable. I observe with pleasure that Dr. Buckland broadly assumes what I have elsewhere termed the metamorphic theory, having stated in his 6th chapter that beds of mud, sand, and gravel, deposited at the bottom of ancient seas, have been converted by heat and other subterranean causes into gneiss, mica slate, hornblende slate, clay slate, and other crystalline schists. But if this transmutation be assumed, it must also be admitted that the obliteration of the organic remains, if present, would naturally have ac-

companied so entire a change in mineral structure. The absence, then, of organic fossils in crystalline stratified rocks, of whatever age, affords no presumption in favour of the non-existence of animals and plants at remote periods.

The author, however, in another part of his Treatise contends, that even if the strata called primary once contained organic remains, there is still evidence in the fundamental granite of an antecedent universal state of fusion, and consequently a period when the existence of the organic world, such as it is known to us, was impossible. There was, he says, one universal mass of incandescent elements, forming the entire substance of the primæval globe, wholly incompatible with any condition of life which can be shown to have ever existed on the earth*. Believing as I do in the igneous origin of granite, I would still ask, what proof have we in the earth's crust of a state of total and simultaneous liquefaction either of the granitic or other rocks, commonly called plutonic? All our evidence, on the contrary, tends to show that the formation of granite, like the deposition of the stratified rocks, has been successive, and that different portions of granite have been in a melted state at distinct and often distant periods. One mass was solid, and had been fractured before another body of granitic matter was injected into it, or through it in the form of veins. In short, the universal fluidity of the crystalline foundations of the earth's crust can only be understood in the same sense as the universality of the ancient ocean. All the land has been under water, but not all at one time; so all the subterranean unstratified rocks to which man can obtain access have been melted, but not simultaneously.

Nor can we affirm that the oldest of the unstratified rocks hitherto discovered is more ancient than the oldest stratified formations known to us; we cannot even decide the relations in point of age of the most ancient granite to the oldest *fossiliferous* beds.

But why, I may ask, should man, to whom the early history of his own species and the rise of nations presents so obscure a problem, feel disappointed if he fail to trace back the animate world to its first origin? Already has the beginning of things receded before

* Buckland's Bridgewater Treatise, vol. i. p. 55.

our researches to times immeasurably distant. Why then, after wandering back in imagination through a boundless lapse of years, should we expect to find any resting-place for our thoughts, or hope to assign a limit to the periods of past time throughout which it has pleased an omnipotent and eternal Being to manifest his creative power?

But it is not my intention to advert now to these and other points on which I happen to differ from Dr. Buckland. I would rather express the gratification I feel in finding myself in perfect accordance with him on so many subjects. His work is admirably adapted to convey instruction on organic remains, and other departments of geology, both to beginners and to those well versed in the science, and is characterized throughout by a truly philosophical spirit, which betrays no desire to adhere tenaciously to dogmas impugned or refuted by the modern progress of science. On the contrary, the author has abandoned several opinions which he himself had formerly advocated; and although still attached to the theory which teaches the turbulent condition of the planet when the lias and other fossiliferous rocks were formed, and the general insufficiency of existing causes to explain the changes which have occurred on the earth, he yet refers in almost all parts of his book to the ordinary operations of nature to explain a variety of phænomena once supposed to be the result of causes different in kind and degree from those now acting.

I have now, Gentlemen, only to offer you my acknowledgements for the high honour conferred upon me by my election to fill the President's chair for the last two years; and it is a source of great satisfaction to me to feel assured of the continued prosperity and usefulness of the association when I resign my trust into the hands of a successor so distinguished for his zeal, talents, and varied acquirements as Mr. Whewell.

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