PROCEEDINGS

AT THE

ANNUAL GENERAL MEETING,

19TH FEBRUARY, 1847.

AWARD OF THE WOLLASTON MEDAL AND DONATION FUND.

AFTER the Reports of the Council and Committees had been read, the President delivered the Wollaston Palladium Medal, awarded to Dr. Boué, to Sir Roderick Murchison, addressing him as follows:—

SIR RODERICK MURCHISON,

In presenting to you, as the representative of your friend Dr. Boué of Vienna, the Wollaston Palladium Medal, I cannot better set forth his claims to the honour than by repeating the terms of the award of the Council. This distinction has been conferred on him "for the zeal, intelligence and perseverance with which he has devoted himself, both in the field and in the study, to the attainment and diffusion of geological knowledge during the last thirty years; for his valuable and original investigations in Scotland, the south of France, Italy, the mountain regions of Bavaria, Wurtemburg, Switzerland and the Tyrol, Austria, Illyria, Hungary, Transylvania, &c.; for his scientific researches in European Turkey; for his industry in collecting materials and his skill in arranging them, as exemplified in his geological maps, particularly those of Europe and the World, and in numerous other publications; all tending to facilitate the study and advance the progress of Geology and its kindred sciences."

So comprehensive an enumeration of the claims of Dr. Boué to the gratitude of geologists,—so ample an exposition of the grounds on which the Council have conferred this distinction upon him, may probably be considered sufficient without my adding another word; but as Dr. Boué is a very old personal friend, I hope I shall be excused if I dwell a little longer upon some of his merits, and give expression to my admiration of his indefatigable zeal, activity and success in the pursuit of science. I first knew him as a medical student at Edinburgh, where, in the lecture-room of Professor Jameson, and in sight of the interesting geological features of the neighbourhood of that city, he first imbibed a taste for our science. While in Scotland, he traversed almost every part of it, as a botanist and geologist; and in his inaugural dissertation for his doctor's degree in 1817, he pointed out the influence of geological structure on the flora of a country, illustrated by examples drawn from Scotland. Soon after he left Edinburgh he published his '*Essai Géologique* *sur l'Ecosse,*' a most remarkable work to have been accomplished in so short a time by one individual, a young man, especially considering the state of the science at that time. He was then, too, labouring under the disadvantage of having been imbued with the system of Werner, at that time exclusively taught by Professor Jameson: "J'ai suivi," he says in his introduction, "dans mon travail les principes de son école." But in justice to my excellent friend Professor Jameson, it must be said, that although he then taught an erroneous creed, he inspired his scholars with a devotion to science which led to their conversion to a sounder faith, as the same devotion to the cause of sound Geology afterwards led their master; and in the same sentence from which I quote the above words, his attached pupil says, "J'ai mis à profit les intéressantes leçons de M. Jameson." But Dr. Boué was too acute and able a man to continue long fettered by the dogmas of any school; he read the volume of nature himself, without the aid of the Freyberg Professor as an interpreter, and he had the merit of being one of the first who pointed out to continental geologists the unsoundness of the Wernerian hypotheses. Humboldt frequently alludes to this first work of our distinguished Foreign Member, in his 'Essai sur le Gissement des Roches,' and always with approbation; and even the severe MacCulloch speaks of it with comparative respect.

Dr. Boué next brought out various Memoirs on the Geology of France and Germany, the fruits of his researches during several summers occupied in exploring these countries; and in these he was the first to maintain that the Muschelkalk and Quadersandstein of the Germans were not identical with any English formations, but distinct beds. These memoirs were embodied in his 'Geognostical Picture of Germany.' He undertook the difficult and dangerous task of exploring European Turkey, which occupied him several years, the results of which he published in an elaborate work, which gives the first authentic account of the geology of this little-known region. His various journeys were undertaken at his own expense: he never accepted any public appointment, although the Chair of Geology at Geneva was offered to him some years ago through the influence of Professor De la Rive and others. Dr. Boué was one of the founders of the Geological Society of France in 1830; he and M. Elie de Beaumont were its first Secretaries; he was Vice-President in 1834, when he gave a "Resumé des Progrès des Sciences Géologiques pendant l'Année 1833," which occupies the whole of the fifth volume of the Bulletin of the Society; and in 1835 he was elected its President. He is now resident at Vienna, pursuing his geological researches with unabated ardour. I received a letter from him three days ago, in reply to that in which I announced to him the award of the Wollaston Medal; he regrets his inability to be present to receive it, and he adds, that he is deeply sensible of the unexpected honour that has thus been conferred upon him.

On receiving the Medal, Sir RODERICK MURCHISON replied as follows:

Sir,—The well-merited eulogium you have just pronounced on the scientific labours of Dr. Boué enumerates merits more than enough to entitle any geologist to our highest honour; but permit me to say, that notwithstanding the length of that list of labours, carried on as they were at his own expense and without fee or reward, there is still one subject to which you have not adverted, and which I can estimate the importance of from my own observations, —I mean the researches of our Foreign Associate, seventeen or eighteen years ago, in the Eastern Alps and Carpathians, which led to a most able parallel between these chains.

In examining the former, I derived such essential advantages from an original Geological Map of that region prepared by Dr. Boué, a copy of which was sent by him to this Society, that it gives me peculiar pleasure thus publicly to state, on the part of my fellow-labourer and myself, that, on the question of the age of the Gosau deposits, our antagonist has proved more correct than ourselves; for we now acknowledge that these strata, at least a large part of them, do not exhibit, as we had supposed, a transition into the tertiary series, but form, as Dr. Boué had asserted, a portion of the cretaceous system.

Hoping to revisit Austria in the ensuing summer, (and what pleasure it will give me, I need scarcely say, if my old friend Professor Sedgwick again unites with me,) I shall indeed, Sir, have the sincerest gratification in conveying to Dr. Boué our Wollaston Medal, which I am sure he will doubly value, when he refers to the names of the eminent foreign geologists who, in common with himself, have received this token of the approbation and esteem of their British contemporaries.

The President next addressed Sir Henry De la Beche, Foreign Secretary of the Society, as follows :—

Sir Henry De la Beche,

In the bequest by which Dr. Wollaston established our "Donation Fund," he empowers the Council to apply the annual proceeds, in whole or in part, "in aiding or rewarding the researches of any individual or individuals, of any country." By virtue of that power, and ever anxious to act in accordance with the liberal desire of Dr. Wollaston, the Council have this year awarded the balance of the proceeds, after providing the Medal, amounting to Thirty Pounds, to M. Alcide d'Orbigny, to assist him in the publication of his palæontological works now in progress.

The researches of M. Alcide d'Orbigny have contributed new material to all departments of Natural History. During his eight years' sojourn in South America, he devoted himself entirely to the service of science; and his great work, the 'Voyage dans l'Amérique Méridionale,' will be an enduring monument of his labours. But it is for the services he has rendered to Geology through the application of his zoological knowledge to the determination and description of fossil remains, that we have especially to be grateful. His 'Paléontologie Française' is a work as important to the English as to the French geologist. That part which relates to the cretaceous strata is nearly completed, and forms in itself one of the finest and most extensive palæontological monographs extant. The descriptions therein given are full and well drawn up, and the figures which accompany them are unrivalled for beauty of execution. It is in the hope of contributing towards the continuation and completion of this great undertaking, that the Council now offer to M. d'Orbigny such assistance as lies within their means. Important as is the Cretaceous section of the 'Paléontologie Française,' the continuation of the Oolitic division, as yet only commenced, would be, if possible, even of more consequence to our science in England. A monograph of recent and fossil Crinoidea is another of M. d'Orbigny's works, which has as yet proceeded but a short way, and I scarcely need say how valuable such an essay would be, if complete. The memoirs of this distinguished naturalist upon the fossils of South America, on the secondary fossils of Russia, and many others of minor extent, all bear testimony to his talents and industry, and to his ardent zeal for science. Few living naturalists have sent forth such a mass of valuable work, in the descriptive and iconographical departments of Palæontology; and, perhaps, none but himself would have the courage to contemplate such a gigantic undertaking as the 'Paléontologie Universelle des Coquilles et des Mollusques,' combined with a complete history of existing species, recently announced, and even commenced by M. Alcide d'Orbigny.

Sir Henry de la Beche said in reply:—I entirely concur in all the remarks which you, Sir, have just made respecting the merits of M. Alcide d'Orbigny, and the importance to our science of promoting, by all the means in our power, the publications in which he is engaged; and I highly value the privilege, which my official position in the Society gives me, of being the channel for such a communication to M. d'Orbigny as the present.

After the other proceedings had been completed, and the Officers and Council had been elected, the President proceeded to address the Meeting.

ANNIVERSARY ADDRESS OF THE PRESIDENT,

LEONARD HORNER, Esq., V.P.R.S.

Gentlemen,—I have again the satisfaction of being able to congratulate you on the prosperous state of the Society. At no period has it been in a condition of more effective usefulness; our numbers are greater than at any former Anniversary; we never had a larger proportion of our Fellows actively engaged in various departments of geological science; our finances are in so sound a state, that we live within our income, and are able to publish the papers read at our meetings quickly and with ample illustrations; our collections of books, maps and specimens have been augmented by many valuable donations in the past year, and they are becoming more and more available to those who desire to consult them. We have had no meeting since our last Anniversary without one paper at least of considerable interest, often more than one; and several valuable memoirs are in the possession of the Council, and others in course of preparation by the authors, which will be read during the remainder of the present session. Our discussions have been carried on with the same talent, animation and earnestness by which they have usually been characterized, combined with that good humour and kind feeling between those maintaining different views, which have prevailed at all times, from the earliest days of the Society.

We have never met on these occasions without having had to lament the loss, by death, of some of our Members; but happily, this year we have not been deprived of more than half the number of those whose deaths it was the painful duty of the Council to announce to you at our last Anniversary.

John Bostock, M.D., although not actively engaged in geological inquiries, was a valuable member of our Society for many years. His name stands high in the medical profession as a physiologist, and he devoted much of his time to chemical research. His scientific pursuits embraced a wide field; he took a warm interest in the objects of this Society, particularly in its early days, and he was elected President in 1826. We have in our Transactions a short paper by him, read in January 1835, giving the results of an analysis he had made of the water of a boiling spring in the volcanic island of St. Paul in the Indian Ocean.

The Rev. Richard Hennah was the eldest son of the Vicar of St. Austle in Cornwall; and after having taken his Bachelor's degree at Oxford, became his father's curate. The place where they resided was in one of the richest mining districts of Cornwall, which gave both a taste for mineralogical pursuits; they formed a choice collection of the minerals of the county, especially the ores of copper and tin, a collection that was well known to all in that county who had similar tastes. In 1804 he was appointed Chaplain to the Garrison of Plymouth, and he held the appointment until his death in 1846, in the 81st year of his age.

Although he had little opportunity of extending his geological researches beyond the country in the neighbourhood of his residence, we are indebted to him for much valuable information respecting the fossils of the Plymouth Limestone, which during many years he had examined with great diligence and success. He announced his discovery of organic remains in that rock in a letter to Mr. Warburton in the autumn of 1814, afterwards published in the fourth volume of the First Series of our 'Transactions'; and on the 2nd of April 1819, a paper by him was read, afterwards published in the fifth volume, in which he describes a considerable variety of the remains of Mollusca and of Zoophytes found in various places. In April 1822 he published 'A Succinct Account of the Lime Rocks of Plymouth.' Previously to his researches, doubts were entertained whether that limestone was fossiliferous. Thus, in the above letter to Mr. Warburton, Mr. Hennah says, "It has hitherto been a point in dispute whether the limestone at Plymouth does or does not contain organic remains." He probably had not then read the 'Illustrations of the Huttonian Theory,' for otherwise he would have seen that Mr. Playfair had, twelve years before, discovered a shell in the limestone, at the very spot from which he was then writing. In accordance with a fundamental principle of that theory, that all the strata, even the most ancient, are composed of the detritus of pre-existing rocks, Dr. Hutton maintained that organic bodies might be discovered in what in those days were called the primary strata; and Mr. Playfair, in his 'Illustrations,' announces (and he appears to have considered it a triumphant proof of the soundness of that principle) his discovery of a shell in the limestone at Plymouth. He thus describes it:—"On the sea-shore, on the east side of Plymouth Dock, opposite to Stonehouse, I found a specimen of schistose micaceous limestone, containing a shell of the bivalve kind: it was struck off from the solid rock, and cannot possibly be considered as an adventitious fossil. Now, no rocks can be more decidedly primary than those about Plymouth. Though, therefore, the remains of marine animals are not frequent among the primary rocks, they are not excluded from them; and hence the existence of shell-fish and zoophytes is clearly proved to be anterior to the formation even of those parts of the present land which are justly accounted the most ancient*." M. De Luc visiting Plymouth in 1805, writes thus:—"There I saw the section of the strata of a limestone much resembling the most ancient secondary limestones of the Alps, which contain but very few marine bodies; I observed none in this stone†." Dr. Berger and M. Louis Albert Necker visited Plymouth in 1810, and Dr. Berger thus speaks of the limsetone, in his paper published in the 1st volume of the First Series of our Transactions, p. 103:—"At Plymouth the cliffs on the shore are of limestone, which I examined leisurely. I did not discover in it any impressions of organic bodies, and I did not hear that they have ever been found in it; at least, if any do exist, they are very scarce." Dr. Thomas Thomson sought carefully for them, but without success ‡. Yet these rocks belong to that series which, under the division called "Plymouth Group," Mr. Phillips, in his work on the Palæozoic Fossils of the counties of Cornwall, Devon, and West Somerset, describes as containing 28 species of Corals, 9 species of Crinoidea, 120 species of Shells, and 9 species of Crustacea. No doubt the far greater proportion of these bodies are from localities where they are not only abundant, but could not be missed by even a casual observer; for in one quarry alone, at Newton, Mr. Austen found 139 organic forms specifically distinct, which he has described in a memoir in the 6th volume of our Transactions. It is true, that

* Page 164.

† Geological Travels, ii. 342.

‡ Annals of Phil. vol. ii, p. 248, 1813.

those in the limestone of Plymouth are not very easily discovered; but the geologists of those days had not yet found out that it is not in the fresh fracture of a crystalline limestone, but on its weathered surface that we are to search for the included fossils with most hopes of success, particularly as regards Corals. It was this which first revealed the secret to Mr. Hennah: he tells us, that on the weathered surface of large blocks he found " the varied figures of Madreporites, which left no doubt on his mind respecting the nature of their contents," and thus encouraged, he succeeded in obtaining "unquestionable proofs" that the limestone enclosed "very numerous and striking varieties of organized remains of marine animals*." To him, therefore, the science is indebted for the evidence of this fact, and for the first delineation of the fossils. Mr. Hennah's claims upon the consideration of geologists, nevertheless, do not rest on his published memoirs, as to his unremitted exertions are due the preservation and accumulation, in one series, of the various organic remains which the public works conducted during his long residence in Plymouth laid open. These collections were most freely rendered available to science, and the loan of them to Mr. Lonsdale, Professor Sedgwick, and Sir R. Murchison, afforded one of the principal sources for determining the relative geological age of the Devonshire limestones. That valuable collection was on his death presented by his son, the Rev. William Hennah, Incumbent of East Cowes, to this Society; the greater part is now in our possession, and the Corals are now at Bath under examination by Mr. Lonsdale, from whom we shall at no distant period receive what will doubtless be a most able report upon them, and which will greatly enhance their value. As the collection contained many duplicates, Mr. Lonsdale, who is ever ready to make great sacrifices for the advancement of science and for the interest of this Society, notwithstanding the very delicate state of his health, went at the request of the Council from Bath to Plymouth, and made the selection; this donation has been perhaps the most valuable acquisition in our Museum during the last year.

But I should not do full justice to Mr. Hennah, were I to confine my observations to his merits as a palæontologist. I had not the pleasure of his personal acquaintance, but Professor Sedgwick, who knew him well, has supplied me with some particulars, from which it may be fairly inferred, that if Mr. Hennah had been able to travel, he would, in all probability, have been a still more extensive contributor to the progress of Geology. I will give the information with which Professor Sedgwick has favoured me in his own words:—" I first saw Mr. Hennah at Plymouth in 1819; at that time he had made a fine collection of the neighbouring fossils, and he had a good general notion of the position of the Plymouth limestone, viz. that it was *over* the slate between Plymouth and Dartmoor, and *under* the slates farther south. Like all older geologists, he believed that the granite was primitive, and that the Cornish slates were among the oldest stratified rocks of the world; hence he had not a true notion

* Succinct Account, pp. 6, 20, 30.

of the place of the Plymouth limestone in the British Series; but he *did* know the near resemblance of several species of his Plymouth fossils to those of the mountain limestone. More than this, he had traced the line of Plymouth limestone into White Sand Bay on the Cornish side of the great estuary, and he had done this by help of fossils. For the mass of limestone thins off, and you can only follow its line by help of some very insignificant reddish calcareous bands with a few fossils (especially encrinites) which he identified with those in his Plymouth limestone. This was really good geological work; and remember it was done before 1819, when he was becoming old and had not the leisure for travelling;—remember too the existing state of knowledge. In 1836 I followed the fossil bands from Plymouth to Fowey, Veryan, &c., and thence to the slates north of the Lizard Serpentine. I was in fact only following out what was a corollary from the work of Hennah before 1819. In 1836 De la Beche had not touched the south-west coast of Cornwall, so my work was original in one sense; but it was, I say, suggested by Hennah's work, and I only took the subject up where he had left it off."

The two eminent persons I have mentioned lived to an advanced period of life; but he whose loss I have now to speak of has been taken from us in the vigour of manhood.

Mr. Charles Turton Kaye was born in London in 1812, and from school went to the East India Company's College at Haileybury in 1829, where he distinguished himself and gained the Classical Medal at his first examination in 1830. In the spring of 1831 he proceeded to India, having obtained an appointment in the civil service, in the presidency of Madras. In the College of Fort St. George he obtained the thousand-pagoda prize for proficiency in the native languages. He was at first employed in the revenue department, and was shortly afterwards appointed Assistant to the Accountant-General of Madras; but in 1838 he received the more important appointment of a Judge at Cuddalore, on the Coromandel coast. Hitherto his attention had been more directed to literature than to science, and accidental circumstances appear to have led him to geological studies. In conjunction with his friend Mr. Brooke Cunliffe, also resident at Cuddalore, now a Fellow of this Society, he examined in 1841 a neighbouring district, which is remarkable from containing fossil wood in great abundance, and where they collected a considerable number of other organic remains. They afterwards obtained many specimens of fossils from a limestone in the neighbourhood of Pondicherry and Trichinopoly. Mr. Kaye came to England on leave of absence in the spring of 1842, bringing the collection with him which he presented in his own name and that of Mr. Cunliffe to this Society. He drew up a short memoir, describing generally the structure of the country from which he had obtained the fossils, which was read on the 29th June 1842; and that memoir, together with two reports, the one by Sir Philip Egerton "On the Remains of Fishes," the other by Professor E. Forbes "On the Fossil Invertebrata of the Collection," have, as you are aware, been recently published, forming the third part of the seventh volume of our 'Transactions.' Professor Forbes tells us that the collection is in every point of view of the highest interest, and that the fossils are as beautiful as they are interesting. The total number of species of Invertebrata is 178, of which 165 are Mollusca, 2 Articulata, 8 Echinodermata, and 3 Zoophytes, the greater proportion being from Pondicherry, or, more properly speaking, from South Arcot, being more within the English than the French territory. The evidence afforded by these fossils as to the age of the beds in which they are contained, makes it clear that they are cretaceous; that in two of the localities in which they were found the beds are equivalent to the Upper Greensand and Gault, and in the other to the lowest division of the cretaceous system in Europe. We are thus indebted to Mr. Kaye for some additional precise and valuable information respecting fossiliferous deposits in Southern India, the great importance of which in a geological point of view must be allowed, when we consider the comparatively limited extent of our knowledge respecting the distribution of animal life in the seas of the tropics during the secondary period. We know little more than what we have learned from the valuable memoir of Captain Grant on the district of Cutch, published in the fifth volume of our 'Transactions,' and from these researches of Mr. Kaye. Although unpracticed in geological investigations, he undertook to follow out the hints afforded by Captain Newbold, and overcame all difficulties, through his sagacity and ardent love of science. His collections in our Museum are a monument of his zeal. During his stay in England he neglected no opportunity of getting together whatever information was likely to aid him in the prosecution of his researches. He returned to India in October 1845, prepared to investigate the interesting district upon the structure of which he had already thrown so much light; but he was shortly afterwards attacked by a disease which terminated his existence in July last, in the 34th year of his age.

I have now to advert to the decease during the past year of one of our Foreign Members, George Gottlieb Pusch. He was a German by birth, but entered, about the year 1816, into the Imperial mining service of Russia, in the kingdom of Poland. The preface to the first volume of his work, entitled a 'Geognostical description of Poland and the Northern Carpathians,' is dated Warsaw, 1829; and in this M. Pusch modestly explains the object he had in view, after ten years of assiduous personal researches. We who are surrounded by many facilities and terms of comparison, may well admire the courage with which a solitary miner, living among the hills of the Mittelgebirge, between Warsaw and Cracow, should have ventured to grapple with the herculean task of putting together the geological description of a kingdom, which should embrace every variety of its deposits and rocks, from the oldest transition formations to the most recent alluvia. With scarcely any valid landmarks to guide him, as established by preceding geologists, M. Pusch so carefully examined this region, that he not only produced an excellent description of its physical geography, relative heights, and mineral constitution, but also developed the ascending series of sedimentary deposits through each great period. The second part of this work, published in 1836, was accompanied by a general geological map of Poland and the North Carpathians, illustrated by local maps, plans and sections; and when I state that this general map contains fifty distinct colours or signs, indicating the various sedimentary strata, and seven colours for the eruptive rocks, besides distinct indications of all the mines, I may convey some idea, however inadequate, of the indefatigable industry of this author.

In the publication of this work, M. Pusch had the merit of fully appreciating the dependence of correct geological results on an accurate acquaintance with fossils. Not contented with simply employing the old generic names of Schlotheim, which when he was educated were considered to be adequate to the explanation of the age of rocks, he mainly grounded his reasoning and inductions on the principle of "strata identified by their specific fossils;" and in drawing a parallel between the Polish formations and those which had been well-established in other countries, he specially appealed to the geology of England and Wales. It would be unreasonable to expect perfection in a work prepared under the great obstacles to which I have alluded, and which, from there being no German press in Poland, was necessarily printed in another kingdom. But notwithstanding his insulated state, M. Pusch clearly laid down the geological outlines of the kingdom of Poland and the adjacent provinces of Podolia and Gallicia, and instituted numerous comparisons which have stood the test of subsequent inquiries. Thus, for example, after describing the transition limestone of Podolia, he suggested that its overlying red sandstone being older than the carboniferous rocks, must be of the age of the Old Red Sandstone of England; and although we are now informed by Sir R. Murchison * that some of the transition limestones which Pusch had compared with the limestone of Sweden are not, like the latter, of Silurian, but of Devonian age, still it is evident that our deceased Associate very nearly reached the truth by the above-mentioned comparison.

In working out the relations of the secondary rocks, M. Pusch devoted a considerable portion of his time to the description of that enormously thick and widely spread series of sandstone, conglomerate, shale, and impure limestone, which constitutes the northern and eastern flanks of the Carpathian chain, under the name of "Carpathian Sandstone," and in this effort he was ably seconded by the Austrian geologist, the late M. Lill von Lilienbach. Indicating its various members upon his map by eight distinct colours and letters, M. Pusch considered the whole group of Carpathian sandstone (though with doubts) to be an intervening mass between the Lias and the cretaceous strata; or in other words to represent the lower part of the Jurassic rocks, whilst he associated with its upper portion the saliferous deposits of Wielieczka, &c. Now, although most of

* Russia and the Ural Mountains, vol. i. p. 39.

the present geologists, including Von Buch and Murchison*, have placed the Carpathian sandstone with its fucoids and nummulites in the Cretaceous system, it must be stated, that M. Pusch having re-examined the ground and fossils in 1830, in company with Professor Zeuschner, came also to the conclusion, that this disputed group might be an equivalent of the greensand series. But as this opinion is expressed in the appendix only to his work, the reader must consult it in order to interpret correctly the classification laid down upon the general map, and the changes adopted by the author, and further to understand the extent to which he admitted the comparisons between the Alps and Carpathians, a memoir on which had at that time been just published by Boué and Keferstein. Seeing, however, that the differences of opinion which prevailed seventeen years ago have not even yet been thoroughly adjusted, in reference to the age of the Carpathian sandstones, and that Professor Zeuschner thinks there are alternations of limestone with Jurassic fossils, let us hope that those geologists who are competent to the task will endeavour to delineate the natural limit between the Cretaceous and Jurassic systems of that region; and in comparing them with their equivalents in the Eastern Alps and the North of Italy, will indicate the different *species* of *Nummulites* which characterize each subformation, and point out to what horizon this striking family of Zoophytes descends in the vertical scale of the secondary formations. Until these distinctions be established, the age of deposits cannot be determined by the presence of Nummulites only; for we know that some species exist in the Eocene tertiary, and others throughout the chalk and greensand; and it is even contended that these fossils also alternate in the Jurassic series. The last congress of Italian naturalists have therefore done well in offering a premium to the naturalist who will best answer this interesting question, and will clearly mark the first appearance of Nummulites, and the diversity of their species in succeeding periods. In short, this desirable end must be accomplished, before the labours of Von Buch, Boué, Lill von Lilienbach, Pusch, and Sedgwick and Murchison, can be brought into accordance with the more recent observations of Zeuschner, Pilla of Pisa, and other writers.

Again, since M. Pusch's researches were carried out, the salt formations on the northern flank of the Carpathian sandstone have been clearly shown by their imbedded fossils to belong to the Miocene tertiary age†; but on this point, whilst he might well be misled by the appearance exhibited by the natural sections of such saliferous masses dipping beneath the secondary Carpathian sandstone, we must not forget that he more nearly approached the truth than any of his predecessors, most of whom, led by English and other European analogies, considered the salt rocks of Wielieczka to be of the age of the New Red Sandstone. Such indeed has been the destiny of all former conclusions which have been exclusively based either

* See Russia and the Ural Mountains, vol. i. p. 265.

† *Ibid.* vol. i. p. 290.

on lithological analogies, or even upon the apparent order of superposition; since it is now well known, that formations frequently lie in inverted positions in those parts of the world wherein the rocks have undergone violent disturbances.

This triumph of palæontology over all other evidences is indeed the peculiar feature of modern geology; and M. Pusch was one of the labourers in the field who have been conspicuous in achieving it. His work on the Palæontology of Poland, published in 1837, was a valuable addition to all that had preceded it, and is much more copious and detailed than the contemporary inquiries of Dubois de Montpereux and Eichwald, who severally described the organic remains of certain parts only of the same country.

It was for these contributions to physical geology and palæontology, that in the year 1841 M. Pusch was elected a Foreign Member of our Society; and when it is recollected that he achieved these results in a region remote from those persons who could best aid him, and gave to us an original Map of the subsoil of a previously unclassified country, I may truly say, that few of our honorary associates have had stronger claims upon our grateful remembrance. For the last few years of his life, M. Pusch had been almost exclusively employed in the tedious and oppressive minutiæ of the administration of the Polish Mines, particularly in the direction of the Coal works on the eastern or Polish limit of the Silesian coal-field.

Progress of Geology.

I will now endeavour to bring before you an outline of some of the more prominent features in the onward movement of the science we cultivate, during the last year. That progress is so rapid, that while it is gratifiying in one sense, it causes a feeling of disappointment almost amounting to despair; for it outstrips the efforts of the most active and industrious to keep pace with, leaving a consciousness that, even within our own domain, if we are to know anything well, we must remain ignorant of much that we should be glad to be acquainted with. And so connected are the various departments of the wide field of Geology, that we are thus constantly doomed to feel the disadvantage of our imperfect acquaintance with other branches of our subject, in working out that which is the special object of our study.

The separate works and the memoirs contained in periodical publications by the geologists of Europe and of the United States of North America have been so numerous, that I might fill my pages by giving only a summary *Catalogue Raisonnée* of the subjects treated of; but as an address so composed would be equally wearisome to me to write and to you to listen to, I have thought it better to follow the same course I did last year, by dwelling on some of those subjects of general interest which are most attractive to myself, and to which consequently I have paid most attention. I will however first advert to some of the larger and more general works.

Among the most valuable of these, I am disposed to name first the

'Memoirs of the Geological Survey of Great Britain.' This is the first volume only of a work which we must all hope will speedily be followed by many more; because they cannot fail to supply us with a large body of facts, carefully collected by most competent observers, which will not only make us more accurately acquainted with the structure of our own country, of which a great part may be said to be known to us as yet only in its principal outlines, but will materially aid in the determination of many of the great problems of Geology. I consider the advantages to be derived from this new institution of our Government, in an economical point of view, important as they will be, subordinate to the higher objects of science it is calculated to promote.

In my Address of last year I adverted to the new importance that had been given to this national establishment, instituted nine years ago, and to the able men by whom the work is to be conducted. With scarcely any exceptions, all geological inquiries have been the fruits of individual research. From the extent of such inquiries, every geologist working by himself, and endeavouring to make out the structure of a country and describe the phænomena in detail, must labour under considerable disadvantages; but in the Geological Survey of Great Britain, there is a combination of forces which we have never, in this country at least, seen applied to the promotion of any one department of science. No department perhaps requires so many different descriptions of force to be brought to bear upon it. The Ordnance Trigonometrical Survey led the way by the preparation of that indispensable requisite in geological inquiries, an accurate Map on a large scale, so ably begun under the direction of General Mudge, and not less ably carried on by his successor General Colby—both early Fellows of this Society. For the more general Survey we have geologists of great practical experience, who have established a high reputation; and when the structure of each region is to be worked out in detail, the special knowledge of the mineralogist, the chemist, the natural philosopher, the zoologist, the comparative anatomist, the botanist, and the palæontologist, will be brought to bear, as required, by means of men of high authority in each branch, and their labours will be illustrated by artists of great skill, all attached to the Survey; forming together a corps of scientific men, for the accomplishment of a great work, not surpassed, I believe, by any similar establishment in any other country.

The Journal of Mr. Darwin, as Naturalist in the Surveying Voyage of the Beagle, contained such an amount of new and important information as to excite a universal admiration of his talents as an observer; and had he given us nothing more, he would by that work have supplied ample evidence of his industry and zeal, notwithstanding almost continual suffering from ill health for several years. But, besides some separate memoirs, he has contributed to our science, as you know, his valuable treatise on Coral Reefs, and that on Volcanic Islands. These however had not exhausted his store, for during the last year he has produced another volume of the highest interest, his 'Geological Observations on South America,' containing in its closely printed pages an amount of reading equal to two-thirds of his Journal. In his first work we had the outlines of these geological observations, but in that recently published we have the outlines filled up with most valuable details, together with many new facts, general observations and deductions, which will be read with much profit by every geologist. In the sequel of this Address, I shall allude more particularly to some of the more striking features of this work.

We received last spring a valuable work from our distinguished Foreign Member, M. Elie de Beaumont—his 'Leçons de Géologie Pratique.' It is an important publication, as giving us the views and opinions of one of the most eminent geologists of France up to a late period, for these Lectures were delivered only three years ago. He informs us that they were given orally, but taken down in short-hand, and revised by himself for publication. Such of you as are not already acquainted with the work will readily believe that a Course of Lectures by so able, so accomplished, and so experienced a geologist, must contain much that is interesting and valuable; and those who seek for minuteness of detail and amplitude of illustration will not be disappointed.

He tells us that he took the *Agenda* of Saussure, published half a century ago at the end of the fourth volume of the 'Voyages dans les Alpes,' as the basis of his plan, but that the present more advanced state of the science had made it necessary for him frequently to leave his guide. Nevertheless, he says,—and it is a proud homage to the genius and sagacity of the great Swiss geologist,—the facts since collected have scarcely ever led him to controvert Saussure, for that philosopher "possessed in an eminent degree the instinct and the presentiment of truth." At the conclusion of his first Lecture he pays another tribute to the great master whom he justly holds up as an example to the pupils he is instructing, in the following terms: "When we read the 'Agenda' with attention, we are surprised how appropriate the greater number of the questions are to the present time. The 'Agenda' are at once the most judicious and the most stimulating guide to observation which the geologist can follow. All that is wanting is to complete them, to extend them, to modify them in some particulars; to establish certain relations between facts less insulated now than they were in his time; and there is perhaps no way in which Geology can be presented to us in a manner more interesting and more instructive. It is that which I shall endeavour to follow in this Course, in which it will be my aim to present known facts in such a way as is most proper for conducting to facts yet to be discovered*."

This last year has also supplied us with a work long wanted, a 'Manual of Chemical and Physical Geology,' by Dr. Gustav Bischof, Professor of Chemistry in the University of Bonn, already well known to us by several interesting chemico-geological researches in the neighbouring volcanic region of the Eifel; and particularly by his work entitled 'Physical, Chemical, and Geological Researches on the

* Page 44.

Internal Heat of the Globe.' There has been no field hitherto more in want of able cultivators than that of Chemistry applied to the elucidation of geological phænomena, one which my able and lamented friend, our former Secretary, Professor Edward Turner, had just entered upon with so much success, when he was taken away from us in the prime of life. We ought therefore to hail with satisfaction the appearance of this work by Professor Bischof. "The earth," he says, "so far as we are acquainted with it, is a great laboratory, wherein, since the creation, chemical processes have been uninterruptedly going forward, and will go on, so long as the earth continues in its orbit round the sun. If we seek to investigate the structure of the earth, if we endeavour to explain the phænomena it presents, and the changes which are unceasingly taking place upon it, we must enter the domains of Chemistry and Natural Philosophy." The first part, that recently published, treats of the aqueous phænomena within and upon the earth; "a knowledge of them," he observes, "of the substances which waters take up, and of the processes to which they mutually give rise, leads us to an explanation of the most important and mighty changes which the earth has undergone, and is still subject to, and to the origin of the sedimentary formations." The second part will treat of the origin of the materials of which these formations are composed, of the crystalline rocks, their constituent parts and their decompositions; of the substances filling the cavities in amygdoloids, of pseudomorphisms, &c.; and a particular attention will be devoted to a subject hitherto little attended to, the lithological differences between primary and secondary formations.

In my Address to you last year, I dwelt so much upon the older series of rocks that I was unable to offer more than a few observations on the recent additions to our knowledge of the tertiary and more modern formations, and on terrestrial changes now in progress. I entered, it is true, at some length upon the subject of boulder formations and erratic blocks, and on some recent discoveries of changes in the relative levels of sea and land, but I did not touch upon the many valuable observations, communicated to us within a short time, on the alterations which the surface of the earth has undergone subsequently to the deposit of the more modern tertiary beds, in the period which approaches historical times, as well as on the terrestrial changes which have since occurred and are now in progress. On the present occasion, I shall confine my review almost exclusively to those contributions received in the last two years, which have enlarged our knowledge of the more modern periods of geological chronology, and even to a small number of these; for I believe that it will be more agreeable to you that I should dwell upon some of the great questions opened up by the authors of the works to which I refer, than that I should occupy your time by brief outlines of the general contents of many works. I will also, in the present as in my last year's Address, abstain from reference to the papers read in this room; not from any want of a due appreciation of their value, but because I deem it superfluous. You heard them read and discussed; they are already in part published, and the rest will shortly appear in our 'Journal.'

The attention of geologists has of late years been more habitually directed to a careful and minute examination of the phænomena of modern changes; and I believe that our theories of the appearances which the older parts of the earth's structure exhibit will be sound in proportion as they are in accordance with the laws which we see governing the modifications that are now in progress. It is in this spirit that Sir Henry De la Beche has devoted nearly twenty introductory pages in his late valuable Memoir, 'On the Formation of the Rocks of South Wales and South-Western England,' to an explanation of existing causes of terrestrial change, in order that his reasonings on the details he is about to describe may be more intelligible and satisfactory. "It may be advisable" he observes, "before we inquire into these facts, to take a brief view of the effects of igneous action, and of the deposit of mineral matter, chemically or mechanically, from or by means of seas, estuaries, and lakes, as they are at present known to us. By comparing this knowledge with the geological facts observed in the district, we shall see how it enables us satisfactorily to account for them, and how far other reasoning may be necessary." As an example of his application of this mode of reasoning, which indeed pervades the whole memoir, I will give the following instance: he is describing a hard indurated slate in the lowest parts of the Silurian system, containing graptolites, and, according to the analysis of Dr. Playfair, so much as five per cent. of carbon, and says, "It would appear that black mud was a common sediment of the time, the colour chiefly due to carbon, which we might infer was derived from vegetable matter. Of what kind that vegetable matter may have been, there would appear no direct evidence; and though we might be disposed to infer that marine plants may have furnished a large part of it, when we regard the quantity of fine sediment of the time and its extent, we should look, in accordance with the mode in which such sedimentary matter is furnished in the present day, to land, its disintegration, and its removal by rivers and running waters to the sea, as among the chief sources of the non-carbonaceous part of this black mud. Hence, and considering the conditions under which the remains of plants are likely to be preserved, it would probably be premature to look more than to plants generally, not altogether excluding animal matter, for the carbon required." Thus he contemplates, with every degree of probability, the existence of a continent, intersected by rivers, clothed with vegetation, and subject to atmospheric sources of disintegration as our present continents are, at that distant period when the materials of the oldest of our sedimentary rocks, the base of our vast series of geological formations, were accumulating at the bottom of a sea.

The lowest stratum of the lowest sedimentary deposit constitutes the limit beyond which we cannot trace the operation of those agencies which are still modifying the structure of the earth; it is the true starting-point of all our speculations into the past history of the globe that rest on authentic evidence; there the proper work of the geologist begins. There must necessarily have been a state of our earth when no sedimentary strata existed, for they could only be formed by the disintegration of pre-existing rocks: the smallest fragment contained in them is an indisputable witness of the truth of this fundamental principle in geology. We know what the mineral nature of these rocks must have been, from the mineral nature of the strata that have been formed out of them; but beyond that, all is obscure: under what forms the materials of these rocks were aggregated, what masses the aggregations constituted, how, in short, the round earth was then composed, are speculations that must be left to cosmogonists, for they are not within the province of the geologist. But if there are fragments in the oldest sedimentary deposits, and if these fragments, whether angular or rounded, are similar to those now forming under our eyes, we legitimately infer that the agents that formed both were alike: if the deposits contain the remains of animals and plants, we also legitimately assume, that the elements necessary for their existence were the same as those which now support animal and vegetable life; it would be unphilosophical to reason on any other principle. The deposition of the oldest sedimentary rocks is therefore the commencement of geological chronology; from that point we trace successive steps in creation, a sequence of changes, to our own time; that far-distant period forms the subject of the first chapter of the voluminous history of the earth, a history recorded in documents of unerring truth; written, it is true, in a language so rich and copious as to be very difficult to learn, but to interpret and arrange these documents is the business and the privilege of the geologist.

M. Elie de Beaumont, in the lectures to which I have referred, has taught his pupils that the only hope of arriving at a right interpretation of the past, is by a careful study of the phænomena subject to our observation, and of the laws by which modern changes in the constitution of the materials of the earth's crust, and in the arrangements of its several parts are governed. One of the first and most striking things that arrests our attention and excites our wonder, in the study of the earth's structure, is the evidence it affords of the immensity of past time, of the incalculable periods that have elapsed during the slow and gradual progress of its formation. Thus M. Elie de Beaumont begins by showing the great duration which we must often assign even to the superficial covering of vegetable soil and alluvium; and he enters at considerable length into this subject in a very instructive manner. Thus, for example, he shows that the covering of vegetable soil, thin though it be, is often proved to be of great antiquity; by the evidence of ancient tumuli, of cyclopean structures and druidical monuments, built on that covering, which has undergone no change since their foundation; that is, for a period of at least 2500 years, and without our being then able to assign any limit to its anterior existence. As another class of evidence, he refers to the instances of the great age of dicotyledonous trees, which M. DeCandolle has brought forward; one of which, a Cypress near Oxaca in Mexico, he estimates to be nearly 6000 years old. "The effects produced," he says, "by the agents now operating on the external surface of the globe, agencies to which some apply, exclusively, the term *actual causes*, constitute a term of comparison, which is indispensable to enable us to appreciate the effects which have been produced by analogous agents in times past. These operations, the effects of the laws of natural philosophy and chemistry, ought ever to be present to the mind of the geologist in his practical observations, because a multitude of circumstances which present themselves in the study of the rocks that compose the earth's surface disclose the operation of some of these agents. Indeed, without we take them into account, it will be impossible to form a just conception of the nature of the greater proportion of rocks, or arrive at a thorough understanding of them."

THE RECENT PERIOD.

Before proceeding to notice some of the more important accessions to our knowledge during the past year, respecting geological phænomena that belong to the most modern period of the earth's history, some of them operations now in progress, I will offer a few remarks on the terms employed to designate certain geological periods.

The sense in which the term "recent" is to be understood, as applied to geology, has not yet been defined. All who use it include, of course, the changes now in progress; but the degree of its extension into time past is by no means a settled point. By some geologists it is confined to the period of which we have authentic records, and has been called the historical period; by others it has been named the *human* period, meaning thereby, that it embraces all the time that has elapsed since the creation of the first pair of the human race; an epoch however which we have as yet discovered no means of fixing with anything approaching to certainty; and some, as for instance Mr. Darwin in his late work on the Geology of South America, apply the term "recent" to alluvial deposits containing remains of mollusca that are all existing species, but also containing remains of extinct mammalia. Whether any of these animals co-existed with man, that is, with man, not merely as existing in the same country, but then existing on any part of the earth's surface, we have no certain knowledge.

But it is not to the term "recent" only that this want of precision is chargeable; the same uncertainty prevails with regard to the terms by which other geological periods are designated, when used, as they are generally understood, to define a certain division of time in the history of *the whole earth*. The indefiniteness is perhaps most apparent in regard to the tertiary deposits, and especially in the more modern of these. In the early days of systematic geology there were only two grand divisions of the stratified rocks, the primary and secondary; the progress of the science called for the separation of the upper portion of the latter into another grand division, the tertiary; and its further progress has shown, that there are subdivisions in the latter that point to great successive changes on the earth's surface, within comparatively modern periods. In 1833 Mr.

Lyell published the third volume of his 'Principles of Geology,' and he there brought forward a division of the tertiary formations into four groups, founded on "the comparative proportion of living species *of shells* found fossil in each*," which he termed Eocene, Miocene, Older Pliocene, and Newer Pliocene. He adopts the same divisions in the second edition of his 'Elements of Geology,' published in 1841, then adding a fifth division, the "Post-Pliocene, including the fossiliferous strata of the Recent, or human period."† "I have adopted the term Post-Pliocene," he says, "for those strata which are sometimes called modern, and which are characterized by having all the imbedded fossil *shells* identical with species now living;"—he takes no account of their containing, or being free from, remains of extinct *mammalia*. The proportions of living species of shells in each division he states to be as follows:—

Post-Pliocene..........	99 to 100	per cent.
Newer Pliocene........	85 — 90	„
Older Pliocene	60 — 70	„
Miocene	20 — 30	„
Eocene	1 or 2	„

A definite order of superposition, from the eocene upwards, was of course implied as an essential condition of the classification throughout the whole range of deposits. The term *pleistocene* had been proposed by Mr. Lyell three years before, for his fourth division; although he dropped it himself, it has since been occasionally used by other writers.

These terms have usually been understood to mean certain periods or measures of past time. If they apply *to time*, they apply to every part of the earth's surface; that is, as generally understood, at the time pliocene deposits were forming in Europe, *it was pliocene time all over the world*. If we inquire how this scale of geological chronology has been formed, we find that it has been graduated by the results of the examination of deposits in *certain localities*, by different observers, and by a careful comparison of the remains of mollusca contained in these deposits, with those now living *in the neighbouring seas*.

The application of the terms pliocene, miocene, &c. *to time generally*, presupposes that the numerous causes which led to the extinction of existing species and favoured the introduction of new species, had been going on over the whole globe, both in respect of kind and degree, although not necessarily simultaneously in different regions; that is, that the same changes might be brought about in periods of longer duration in one region than in another: that the causes operated in one region on certain species, in another on analogous or representative species; the general effect being, that *an uniformity in the character of the result*, during the epoch in question, was produced all over the globe. Facts already collected appear to some geologists to lead to this conclusion; they maintain that if we extend the period of time sufficiently, a certain class of changes will have taken place, having

* Preface, p. xiii.

† Vol. i. page 210.

such a community of character as to constitute an epoch in time generally, and that it is in this sense we are to understand the pliocene, miocene, and eocene periods respectively. This view may be confirmed by the accumulation of a widely-extended and multifarious body of evidence; but some of the principal causes of the extinction of existing species, and of the introduction of new species, are of a kind that might have come into operation in one portion of the globe, while other parts remained unchanged by similar causes; therefore the synchronism of formations in distant parts of the globe cannot be conclusively determined by evidence that is in its nature inconstant. This leads us naturally to inquire, what the circumstances are on which the distribution and habits of different species of mollusca depend.

Professor E. Forbes has shown, that the distribution of marine animals is determined by three great primary influences, and is modified by others that may be termed secondary or local. The primary are, climate, composition of the sea, and depth: the secondary are, the nature of the sea-bottom, that is, whether it consist of sand or rock, be gravelly or weedy; tides and currents, and the influx of fresh water. It is generally admitted by geologists, that at all periods down to our own times, the surface of the earth has been subject to extensive elevations and subsidences; that plains and lofty mountains have risen where formerly there was sea, and that plains and mountains have subsided and been covered with deep water. It is evident that such elevations and depressions, producing variations in the relative proportions of sea and land, and not only in the extent but in the elevation of the land, must have caused great changes in atmospheric temperature, in the temperature of the sea, in the depths of water, in sea-bottoms, in the direction of currents, and in the influx of fresh water, on different parts of the superficies of our earth, and even on the same parts at different times. But such alterations in the proportions of land and sea could not be synchronous over the whole earth, nor is it probable that in two distinct areas they would be alike in amount or in kind.

Let us, for example, suppose two parts of the ocean (A and B) far distant from each other, under such similarity of condition as to temperature, depths of water, sea-bottom, &c., as to be favourable to the existence of the same or representative species of mollusca; of littoral species, of those inhabiting zones of moderate depth and of deep sea species; let us further suppose earthy deposits going on in each part, and inclosing the remains of the dead mollusca that lived on the rocks and sands and amidst the groves of fuci of its bottom. Let us now suppose subterranean action so to raise the bottom of the part A as to cause shallow water above it: immediately, or soon after, the mollusca capable of existing only in deep water would perish and become extinct in that part, others fitted for shallow water would begin to prevail, and newly-directed currents, caused by the altered form of the land, might bring other species, and the remains of these several new species would, in their turn, be inclosed in the deposits going on in the shallow sea. Let us suppose the number of species that become extinct to amount to 16 per cent. Let us further suppose another change in the neighbourhood of the shallow sea, an elevation of the land to such an extent that perpetual snow would rest on mountains and form glaciers; a change of temperature in the atmosphere and in the adjoining sea would then take place, and such mollusks as were fitted to live only in a mild temperature would perish and become extinct; the same might happen from changes in the sea-bottom by the influx of detritus from the land; and new species adapted to the altered conditions would prevail. Let us suppose that the number of species that become extinct by this second change of conditions, also amounted to 16 per cent.; this last state of things continuing unchanged for a long period, a new exertion of subterranean force raises up the bed of the shallow sea into dry land, and fissures exhibit sections of its structure. A future geologist examines the fossiliferous beds, and he finds a lower series with not more than 68 per cent. of the species living in the adjoining sea; a series of beds above these with about 84 per cent., and these last capped by a series in which all the mollusca are species then existing in the neighbouring sea. He thus finds a series of Older Pliocene, Newer Pliocene, and Post-Pliocene deposits; for he has no proof that the species he considers extinct are living in any other part of the earth.

But while these changes have been going on throughout a long period in this part of the ocean (A), the other part of the ocean (B) has continued without any other change than a greater accumulation of sedimentary deposits on its bottom. But that sea-bottom is in process of time elevated at once into dry land, and when examined by a future geologist, he finds the strata containing littoral species of shells, those that live in zones of moderate depth and some that inhabit deep water, some peculiar to sandy some to rocky bottoms. He goes out with his dredge into the neighbouring seas, and makes a large collection of shells from various depths; and on comparing the two, he finds all the fossil remains in the strata to be species then living in the adjoining sea, and he classes the whole series of beds as post-pliocene. But the changes of conditions in the distant part of the ocean A, and the constancy of conditions in the part B were synchronous; and thus it would appear that, taking the proportions of living species of shells in the beds of the two parts as a standard, older and newer pliocene deposits were forming in the part A, and post-pliocene in the part B at one and the same time, in distant parts of the earth. If therefore the above reasoning be correct, it seems to follow, that while proportions of living species of shells constitute a sound principle for discriminating changes of time, when accompanied by changes of condition, *over limited areas,* two pliocene deposits at distant parts of the earth's surface may not be certain evidence of synchronism. In support of these views, I will quote the concluding sentence of the fourth chapter of Mr. Darwin's new work, to which I shall afterwards refer at some length, viz.—" The facts here given show how cautious we ought to be in judging of the antiquity of a formation from even a great amount of difference between the extinct and living species in any one class of animals; we ought even to be cautious in accepting the general proposition, that change in organic forms and lapse of time are at all necessarily correlatives*."

So also if animals inhabiting shells are subject by revolutions in climate, or other causes, to remove from one region to another, and such we know to be the case, that removal may take place after the shells of several generations of the species may have been imbedded in sediment. The species may become extinct in the first region, and prevail for a long time in that to which they had removed, and their shells may, in like manner, become imbedded in stone. Thus strata in distant places, although characterized by shells of the same species, may not be of synchronous formation.

I make the foregoing observations however with great diffidence, I throw them out as suggestions for consideration; they relate to matters of great complexity and difficulty, but which are of fundamental importance in our researches into the earth's history, and they are in a very unsettled and uncertain state. The opinions I have now hazarded are, in some degree, at variance with those of a geologist of great authority, one from whose conclusions I very rarely differ, and never without doubting the soundness of my own judgment. Thus, Mr. Lyell, after comparing the tertiary formations of North America and Europe, of which he has treated in his 'Travels,' and in papers published in our Journal, has come to the conclusion that the Eocene and Miocene formation of the United States, as determined by the relative proportions of recent and extinct species of fossil shells, are truly contemporaneous in age with the deposits termed by him Eocene and Miocene on this side of the Atlantic. With some species identical with those of the neighbouring seas, they contain a great number of forms which he regards as "representative." The synchronism he considers to be established not only by agreement in the relative position and the characters of the whole fossil fauna, but by the same kind of evidence as that which induces geologists to consider the coal-fields of the United States and the cretaceous strata as equivalents in time and position with the groups similarly designated in Europe. The numerous points of agreement in the palæontology of the successive tertiary and post-pliocene formations of America and Europe he believes to have been brought about by the predominant influence of climate controlling the minor effects of local geographic revolutions, and causing a near approach to a uniform rate of fluctuation in the organic world throughout the whole northern hemisphere, from the Eocene to the recent periods.

By whatever names we designate geological periods, there appear to exist no clearly defined boundaries between them in reference to the whole earth; such a marked line may be seen in particular localities, but every year's experience, and our more intimate acquaintance with the phænomena exhibited in different countries, and with the distribution, structure and habits of animals and vegetables, teach us that there is a blending, a gradual and insensible passage from the lowest to the highest sedimentary strata, particularly in respect of

* Geology of South America, p. 105.

fossil remains. The terms we employ to designate formations can only be considered as expressing the general predominance of certain characters, to be used provisionally, as a convenient mode of classifying the facts we collect, whilst that knowledge is accumulating which, in after ages, will unravel the complicated changes that belong to the successive periods into which the history of the structure of the whole earth may be divided.

GEOLOGICAL CHANGES NOW IN PROGRESS.

Among the most remarkable of those recorded during the past year, none is more instructive, from the magnitude of its operations, than the formation of the alluvial plain of the Mississippi, of which we have received an account from Mr. Lyell, the result of inquiries and personal observation made by him during the spring of last year, along a considerable part of the course of that river from its mouth to the junction of the Ohio. He brought before the British Association last September the principal facts he had collected, and the conclusions he had been led to deduce from them, respecting the progress of that vast accumulation of sedimentary matter, and he has referred to them in greater detail in the seventh edition of his 'Principles of Geology,' just published.

The alluvial matter brought down by this river and its tributaries has formed a tract of level land, which extends from the embouchure in the 29th degree of latitude to Cape Girardeau in the state of Missouri, fifty miles above the junction of the Ohio, in latitude 37° 20′, a distance, in a direct line from S. to N., of 576 miles. The width of the plain varies considerably, between thirty and eighty miles, which last dimension it attains in lat. 34°; and it has been estimated by Mr. Forshey to occupy an area of 31,200 square miles, with a circumference of about 3000 miles; thus exceeding the area of Ireland. That part of the plain which, according to the usual language of geographers, would more properly be called the delta, viz. all that lies below the point where the highest arm, or the Atchafalaya, branches off from the Mississippi, is estimated at nearly one-half of the whole area, or 13,600 square miles. This delta, which spreads out into a vast level region, extending beyond the general coast, is in form very unlike the delta of the Nile, for the main stream does not divide into two separate branches to form the two sides of a triangle, nor is there the curvilinear base towards the sea; a tongue of land protruding fifty miles into the Gulf of Mexico, through which the main river flows until near its extremity, where the water is discharged into the sea by four main channels, or Passes as they are called. The plain at Cape Girardeau is not more than 200 feet above the sea-level, so that the rise is only about *four inches* in a mile. Mr. Lyell states the rise at *three inches* in a mile, but he takes the distance at 800 miles, following the sinuosities of the river. Small as this is, it is much greater than the rise in the valley of the Nile from the sea. That alluvial plain is 420 miles in extent from the first cataract to the apex of the delta; from that last point to the Mediterranean, in a direct line, is about 102 miles; the base between the eastern and western branches of the river being 187 miles. The fall from the first cataract to the sea is only two inches in a mile*, and M. Elie de Beaumont states that the bed of the river at Cairo, which is sixteen miles above the head of the delta, is 16 feet 4 inches above the Mediterranean, which gives a fall of 1·9 inch in a mile†.

According to Mr. Lyell, the deposit of the Mississippi "consists partly of sand originally formed upon or near the banks of the river and its tributaries, partly of gravel, swept down the main channel, of which the position has continually shifted, and partly of fine mud slowly accumulated in the swamps. The further we descend the river towards its mouth, the finer becomes the texture of the sediment‡." A large portion of this alluvial deposit, together with the fluvio-marine strata now in progress, near the mouth, is intermixed with much vegetable matter, derived from the prodigious quantity of drift-wood floated down every summer during the freshets. "In excavating at New Orleans, even at the depth of several yards below the level of the sea, the soil of the delta contains innumerable trunks of trees, layer above layer, some prostrate, as if drifted, others broken off near the bottom, but remaining still erect, and with their roots spreading out on all sides, as if in their natural position. In such situations, they appeared to indicate a sinking of the ground, as the trees must formerly have grown in marshes above the sea-level§."

The east and west boundaries of the alluvial region, for about five degrees of latitude above the head of the delta, consist of bluffs or cliffs, from 50 to 250 feet in perpendicular height, which continue as far north as the borders of Kentucky, not far below the head of the plain. "They consist in great part of loam, containing land, fluviatile, and lacustrine shells, of species still inhabiting the same country. These fossil shells occurring in a deposit resembling the Loess of the Rhine, are associated with the bones of the mastodon, elephant, tapir, mylodon, and other megatherioid animals; also a species of horse, ox, and other mammalia, most of them extinct species. The loam rests at Vicksburg and other places on Eocene or lower tertiary strata, which in their turn repose on cretaceous rocks." As these bluffs are composed of alluvial and freshwater deposits, we may suppose that they were once overflowed by the river, at a time when the relative level of the Mississippi was very different. During the upheaval of the country, the river may have gradually carried away by denudation large portions of the loam, reducing the alluvial plain to its present level, and leaving bluffs bounding the region from which a large quantity of matter has been removed. Mr. Lyell appears to be of opinion that, in modern times, the levels of the great plain of the Mississippi have been chiefly altered by movements of subsidence, such as those which in 1811–12 gave rise to new lakes and what is called "the sunk country" near New Madrid in Missouri. That it was subsidence rather than upheaval is, he thinks, "established by the fact, that there are no protuberances of upraised alluvial soil projecting above the level surface of the great plain. It

* Newbold, Geol. Proceedings, vol. iii. p. 783.
† Leçons de Géologie Pratique, tome i. p. 476.
‡ Principles of Geology, 7th edit. page 216. § Ibid. page 214.

is true that the gradual elevation of that plain by new accessions of matter, would tend to efface every inequality derived from this source; but we might certainly have expected to find more broken ground between the opposite bluffs, had local upthrows of alluvial strata been of repeated occurrence*."

Of the depth of the alluvial deposits spread over this vast region we as yet know little. Mr. Lyell was informed by several engineers that borings 600 feet deep were made near Lake Pontchartrain, north of New Orleans, in which the bottom of the alluvial matter is said not to have been reached. It is possible that the upper part of the plain may have been formed by the gradual raising of the river's bed by accumulating detrital matter, as that of the Po and other rivers has been; but it is probable, I think, that the greater part has been formed by the discharge of the alluvial matter into the sea, at the mouth of the river, together with deposits on each side when the stream, swollen by floods, periodically overflowed its banks: that at one time this basin of the Mississippi was an arm of the sea, penetrating into the land, which has been gradually filled up, the mouth of the river advancing as the accumulation went on, to its present position. If the alluvial matter be of such vast thickness, as the sinkings at Lake Pontchartrain seem to indicate, I do not see how it could have been accumulated in any other way, unless indeed we suppose an uninterrupted slow subsidence of the valley for a vast period of time. This supposed bay or deep inlet may have been of considerable depth throughout its whole length, or it may have had a bottom gradually shallowing northward; and the nature of the bottom, whether deep or shelving, would of course determine the amount of thickness of the accumulating matter, and the rate of advancement of the mouth of the river southward. As a basis for calculating the time that may have elapsed since the alluvial plain began to be formed, Mr. Lyell assumes that the newly deposited soil has a depth over the whole area of the delta, comprising 13,600 square miles, equal to that which has been penetrated vertically north of New Orleans, or 600 feet; that is, similar to the average depth which has been ascertained to prevail in the waters of the Gulf of Mexico, between the southern point of Florida and the Balize, or mouths of the Mississippi; but for the sake of facility of calculation, he assumes it to be one-tenth of an English mile, or 528 feet.

From experiments made by Dr. Riddell of New Orleans, Mr. Forshey, and Dr. Carpenter, on the mean annual solid contents suspended in the water of the Mississippi, and from observations on its mean width, depth and velocity, and thence the mean annual discharge of water, the number of cubic feet of solid matter annually brought down by the river has been estimated; that is, the finer matter only, that which is suspended, and not taking into account the coarser materials, which, throughout the delta and over a great part of the plain above, from its very slight inclination, would probably amount to very little. The estimated annual quantity being spread over the computed area of the delta, that is, 13,600 square

* Ibid. page 216.

miles, would be of such a thickness, that to accumulate it to a depth of one-tenth of a mile, a period of 67,000 years must have elapsed; and supposing the alluvial matter in the plain above the delta to have only one-half the above-estimated depth, and to be only of the same area as the delta (although it is somewhat greater), and that the solid contents of the year were spread over the united area, a period of 100,500 years would be required for the formation of the whole plain. The proportion of the thickness that would be derived from the coarser unsuspended materials and the drift wood, vast in amount as the latter is every year, Mr. Lyell holds to be more than compensated in the calculation, by the quantity of suspended matter which would not fall down before the river-water was carried far out to sea. The depth of the alluvial soil above the head of the delta is, in the absence of borings, estimated from this, that the river is continually shifting its course in the great plain, cutting frequently to the depth of 100, and sometimes to the depth of 250 feet.

This calculation can only be considered as a first attempt to give an approximate numerical value to a part of one of the periods in geological chronology, and that period the most modern in the series. Throughout the whole range of geological changes, from the lowest sedimentary stratum to that of deposits within the historical time, an attentive study of the phænomena of each impresses us with a conviction, almost amounting to a demonstrated truth, that a vast lapse of time is indicated by each great successive change—periods however to which we can assign no definite amount, from the absence of the necessary data by which we can obtain an unit. But if a geological change be in progress in our own time, such as the deposit of an alluvial soil by a river, and we are able to estimate the amount, say one foot in thickness, between two fixed periods A and B, B being the earlier period, if the total deposit be 50 feet thick, and be of an uniform composition and character throughout, it is fair to infer that each of the 49 feet below B must have required the same time for its deposition as that between A and B; unless it can be shown that there are circumstances which would cause an acceleration or a retardation of the process. If, as in Egypt, there were in the valley of the Mississippi monuments of human art of remote antiquity, the age of which was pretty accurately known, round which the alluvial matter was accumulated, the monuments resting on a soil of the same nature, we should have a better measure, a standard scale of some accuracy, to begin with; and if we had sections or borings at various points in the valley, by which we could ascertain the depth and nature of the alluvial deposit, and whether the bottom of the valley was level or sloped gradually from the Gulf of Mexico to the head of the plain, we should be able to form a tolerably correct estimate. As it is, the above calculation can only be considered as a reasonable deduction from the limited data we have yet obtained; and it will no doubt serve as a stimulus to future observers to collect materials for the working out of a problem so interesting and important, not only in the valley of the Mississippi, but in other localities favourable for such inquiries.

Mr. Lyell, in his 'Travels in North America,' published within the period of the review I am now taking, has given us another measure of time, also within the most modern period of geological chronology, in his observations on the recession of the Falls of Niagara, by the slow but incessant action of the water on the rocks over which it flows. The order of succession, and the geological age and position of these rocks have been ably described and illustrated by Mr. James Hall in his 'State Survey of New York,' to the accuracy of which descriptions Mr. Lyell has borne testimony. As the strata are various in their nature and hardness, there must have been a great inequality in the rate of wear at different parts; and not from that cause alone, but also from the inclined position of the strata. From the observations that have been made as to the amount of waste within a known period, Mr. Lyell is inclined to think that a foot a year would be the most probable rate, if the retrograde movement could be assumed to have been gradual. From the causes above stated, it would probably be sometimes slow and sometimes rapid; but if we take a foot for the mean annual waste, as the length of the ravine, which has been demonstrably worn by the river, from Queenstown to the present position of the Falls, is seven miles, 36,960 years must have elapsed between the present time and the period when the Niagara formed a cataract over a precipice at Queenstown. Many of the species of fluviatile and terrestrial testacea now living in that region must have been created before that period, for Mr. Lyell has shown, and he was the first to collect the evidence of the fact and to appreciate its importance, that before the river began to cut out the ravine, it must have flowed over a plain of alluvial soil in which the remains of existing land and river shells had been deposited, the remains of its former banks having been discovered by him on both sides, at the top of the cliffs which now bound the river course.

In the recently published work on Lycia by Lieut. Spratt and Professor Forbes, the latter gives a chapter on the geological structure of that part of Asia Minor, which contains some interesting facts relating to changes now in progress. The land has been subject to elevations and depressions, not only in very modern geological times, but even within a period not very remote in the historical epoch. A sarcophagus stands in the water in the Bay of Macri, the site of the ancient Telmessus, which is bored by marine animals to a third of its height, indicating a subsidence and subsequent rising of the land, like that on which the ruins of the temple of Jupiter Serapis stand, in the Bay of Naples, but with this difference in the circumstances of the two cases, that there are no volcanic foci known to have been in activity in the historic æra in that part of Asia, none nearer than the island of Santorin in the Archipelago, a distance of nearly 200 miles westward; but earthquakes almost annually convulse the country.

The port of the ancient city of Patara is closed up by accumulations of sand, and Cannus, which was a seaport in the time of Strabo, is now two miles inland, and its harbour is a freshwater lake, from whence the waters have a fall to the sea.

A great part of the plain of Pamphylia is composed of modern travertine, beds of which are forming at the present time, from the prevalence of springs loaded with carbonate of lime held in solution by carbonic acid, as is common in countries bordering on volcanic regions. This travertine, where it reaches the coast, forms cliffs from 20 to 80 feet high, and at various distances inland there is a repetition of heights resembling the line of cliffs. Along the shores of Lycia there is an extensive formation, now in progress, of a conglomerate composed of water-worn pebbles, interstratified with beds of mud and sand, cemented into a hard rock by calcareous infiltrations, but yet so preserving the external appearance of a shingly beach, that boats are in danger of striking against a rock, where those unacquainted with the coast are expecting to run them up on a loose yielding bed.

By the blocking up of the mouths of some of the rivers, by shifting sands, lagoons and marshes are formed; the water is at first salt, but if the barrier endures long enough, it becomes fresh, and is peopled with freshwater mollusca. Thus at Macri, where such changes have taken place within the historical period, as already stated, lagoons of this kind are filled with myriads of the *Cerithium mammillatum,* a mollusk capable of enduring great changes in the quality of its native element. These alternations of salt, brackish and fresh water, must produce deposits with corresponding changes of character, so that, as Mr. Forbes observes, a section of the plain would doubtless show many alternations of such strata; and he adds this important remark:—"The history of life upon our globe, the in-coming of new species and the perishing of old ones, is only the history of elevations, depressions, and temporary conditions, varied by an occasional convulsion, differing only in degree from those which have determined the zoo-geological features of the coast of Lycia."

A case analogous to such modern formations is described by Mr. Forbes as occurring in the older pliocene freshwater beds in the island of Cos, and which exhibits a phænomenon of great importance in palæontology, one particularly instructive to those who have a tendency to multiply species on insufficient grounds:—"The freshwater beds in Cos contain mollusca of the genera *Paludina, Melanopsis,* and *Neritina,* distributed in three distinct horizons, throughout the vertical thickness of the stratum, each horizon in the series being characterized by a peculiar form of Paludina and of Neritina, not present in the other two; and in the two lower horizons there are two species of Melanopsis peculiar to each. They have the appearance of very distinct well-marked species, but on careful examination it is evident that they are of the same species, presenting varieties caused by the animals having lived in alternations of fresh and salt water." He then enters into a minute explanation of the operation of these changes of condition, and thus concludes:—"Such an explanation is consistent with what we now know of the modes of variation among freshwater mollusca, which, at first glance, appeared to afford strong support to the notion of a transmutation of species in time."

When certain peculiar marks on the surface of slabs of new-red-sandstone were held by Dr. Buckland to be the scattered irregular inequalities raised by the pelting of a shower of rain on a surface of yielding argillaceous sand, his theory was received with no small incredulity; and some smiled at what they held to be an overstraining of his known ingenious fertility in applying ordinary occurrences in the explanation of geological phænomena. But the sagacity and soundness of his theory of these appearances has now been generally admitted. Mr. Lyell not only observed similar impressions of rain-drops on the surface of beds of new-red-sandstone in New Jersey, but he saw them recently formed on a deposit of red mud, thrown down at the mouth of the river Patapsco near Baltimore, of which he was able to bring away some consolidated layers; and he says that, in addition to the smaller cavities due to rain, there are larger ones, on these layers, more perfectly circular, about the size of large currants, which have been formed by air-bubbles in the mud. On the shore of the Bay of Fundy he found that the upper part of the mud had been baked hard by a hot summer sun, to a depth of several inches, and in its consolidated state exactly resembled, both in colour and appearance, some of the red marls of the new-red-sandstone formation of Europe. In some places it was pitted over with small cavities, which he was told were formed by a shower of rain which had fallen eight or ten days before, when the mud was still soft. In like manner he observed the impressions of footmarks which have been met with in several situations in Britain, in Germany, and in Connecticut in North America, illustrated by the same muddy shore of the Bay of Fundy. "I observed," he says, "many worm-like tracks, made by Annelides which burrow in the mud; and, what was still more interesting to me, the distinct footmarks of birds in regular sequence, faithfully representing in their general appearance the smaller class of ornithichnites of high antiquity in the valley of the Connecticut before described*." He ascertained that the markings were the recent footprints of a Sandpiper (*Tringa minuta*), and he was able to bring away two slabs of the hardened mud with these impressions, which he has deposited in the British Museum. What was highly important, as showing the identity of origin of these recent footmarks with that of the impressions on the ancient sandstones, he ascertained that similar footprints existed in inferior laminæ of the hardened mud. He also observed instances of those ramifying elevations on the surface of slabs, of which we had last year a description and drawing by Dr. Black, in the account he gave us of a very fine specimen from Cheshire, in the Museum of the Manchester Geological Society, accompanied in that specimen by numerous footprints; the casts of old cracks standing out in relief. On the shore of Georgia he observed footmarks in progress of preservation; they had been left by racoons and opossums on the sand during the four hours immediately preceding, and were already half filled with fine blown sand; showing the process by which distinct casts of the footsteps of animals have been formed on a stratum of quartzose sandstone.

* Travels in North America, vol. ii. p. 168.

In my address last year I referred to the instances given by Mr. Darwin of an elevation of the land on the western coast of South America. Those referred to had occurred after the creation of species of mollusca now living in that region, but they do not afford any evidence of belonging to the recent period, but must be referred to the pleistocene epoch, and as such I shall have occasion to speak of them in an after-part of the present Address. In the work recently published by Mr. Darwin, he gives a detailed description of several instances of elevations that have taken place in recent times, presenting the same characters as those of earlier date; and expresses his opinion that this movement of the land, although subject to intervals of rest, is now, as it has been at all former periods of geological time, one of the main causes of the revolutions to which the surface of the earth is unceasingly subject. "The time, I believe, will come," he says, "when geologists will consider it as improbable that the land should have retained the same level during a whole geological period, as that the atmosphere should have remained absolutely calm during an entire season*."

The island of San Lorenzo near Lima is upwards of 1000 feet high, and in one part of it there is a ledge of rock, containing an accumulation of recent shells two feet in thickness, and above a mile in length; the highest part of which is 85 feet above high-water mark, the shells being in nearly the same proportional numbers with those on the existing beach. Several of the univalves have evidently lain long at the bottom of the sea, for their insides were incrusted with balani and serpulæ. In the midst of these shells Mr. Darwin found a piece of woven rushes, and another of nearly decayed cotton string, undistinguishable from similar things found in the burial-grounds of the ancient Peruvians. These discoveries, and the whole appearance of the bed of shells, seemed to him to render it almost certain that they were accumulated on a true beach, since upraised 85 feet, after the Indians inhabited Peru. The island of Lemus, in the Chonos Archipelago, was suddenly elevated by an earthquake in 1839. An English resident stated to him that a part of the island of Chiloe had been raised four feet in four years, and that the change had been gradual. The island of Mocha, 70 miles north of Valdivia, was uplifted two feet during an earthquake in 1835. At Valparaiso, between the years 1614 and 1834, there had been a rise of the land of 19½ feet, of which between 10 and 11 appeared to have been subsequent to 1817. The elevation had been by insensible degrees, with the exception of the year 1822, when the great and celebrated earthquake of that year raised the land suddenly three feet over a considerable extent, and a slow rise of the land is considered by residents there to be now in progress. There is also evidence of subsidence on parts of the coast for some distance south and north of Callao.

Few countries present on so great a scale the operations of atmospheric agency in disintegrating and transporting the materials of the land as Central Russia does. The inferior solid rocky structure of the country, as we learn from the recent work of Sir R. Murchison, is seldom

* Page 26.

exposed; the surface, to a considerable depth, being composed of clay, sand, gravel and boulders. These, over great tracts, are the detrital matter that was accumulated on the then sea-bottom, during the glacial period, the period of the northern drift. Where there are elevated plateaux of these incoherent materials, the ground, during the excessive heat and drought of summer, splits into vast cracks, which often reach a great depth. These, in winter, are filled by accumulations of snow and ice; the thaw of the spring loosens the earthy matter, and a gulley is formed, which widens as it approaches the steep sides of the plateaux, and in the course of a few seasons becomes a broad and deep ravine, through which melted snow, mud and sand, and occasional blocks and boulders, are transported into an adjacent river. These ravines are of such frequent occurrence over large tracts of country, that the quantity of matter carried into the streams must be enormous; this is afterwards transported to lower levels, or to the distant embouchures of the larger rivers, to form the rapidly increasing delta of the Volga, or to silt up the Sea of Azof by the settlements from the muddy waters of the Don. In the spring, large portions of the surface in Russia are covered by water, from the melting of the snow, the higher lands emerging like isles or promontories; "and when it is considered," says Sir R. Murchison, "that such enormous volumes of water have for ages flowed off to the sea through deposits, for the most part incoherent, we can well account for the increase of the deltas within the historic period, at the mouths of all the chief or south-flowing rivers. So great indeed must have been the increment of matter in the Caspian, the Black Sea, and the Sea of Azof, that we must not be surprised to find very essential distinctions between the features of the present lands near the mouths of such rivers, and those which prevailed during the earlier days of their occupancy by man. Thus, freshwater shells common in the Volga have been found at about 300 feet below the city of Astrakhan, which is built upon the mud of that river. By its daily-increasing delta, the Caspian is constantly encroached upon and diminished in area, the shallow water already extending to 40 and 50 miles south of the present embouchure*."

It is interesting thus to trace the progress of change which the solid materials of the globe are destined to undergo, in that vast cycle of decay and renovation which we know from irresistible evidence to have been in progress during all geological periods, and which, if we are to speculate on the future by what we have learned by the past, and by what is going on under our own observation, is likely to continue. Granite pinnacles, upheaved in Scandinavia, were in distant ages split and shivered into fragments by the expansive power of freezing water; and these fragments, collected in moraines, were pushed along by the downward movements of glaciers, and at length reached the sea of the glacial period; at a time when Central Russia was submerged, as we know from very clear proofs, to a depth of at least a thousand feet†. By the transporting powers of water and ice, these fragments of Scandinavian rocks were spread over the sea-bottom, hundreds of miles

* Murchison's Russia, p. 572.

† See my Anniversary Address of 1846, p. 60.

southward. In process of time that sea-bottom, thus formed to a great depth of clay, sand, gravel and boulders, was elevated to the surface, level or unequal according as the elevating force acted with uniform or variable intensity, and formed the land of Central Russia. The incoherent materials, after a long period of repose in the new-formed land, are again subjected to atmospheric agency, broken into smaller fragments or worn down into impalpable mud, to be suspended in water and floated to the mouth of the Volga, or to settle at the bottom of the Caspian in a stratified deposit. There they form a new ground on which mollusca live, whose shells will become buried in the slowly forming stone; and this stone covering a region where we know internal heat to be active, may become metamorphic, and assume a compact or crystalline structure. Thus the same matter which was once a constituent of a granite in the Alps of Scandinavia, after undergoing numberless changes in form and structure, through an incalculable period of time, changes however identical with those which we now see in progress, may be hereafter raised up in Asia as the elements of a schistose rock; in like manner as our oldest sedimentary strata must have been derived from the disintegration of pre-existent granites, or other forms of unstratified rock, of which the land was then composed.

You may probably recollect having read, in the newspapers of the autumn of 1845, an account of a quantity of dust having fallen from the atmosphere on the Orkney Islands; it was also said to have fallen to the thickness of an inch on ships in that part of the North Sea. It was supposed to indicate a volcanic eruption of ashes in Iceland; and the conjecture was proved to be correct; for, on the 2nd of September of that year, the great volcanic mountain of Hecla, after a repose of nearly 80 years, again burst forth. On the same day, a quantity of dust fell on a Danish ship in lat. 61° N., and longitude 7° 58′ W. of Greenwich. It blew at the time strong from the N.W. by W. From this point Hecla is 533 miles distant.

We learn from the work of Mr. Ebenezer Henderson *, that between the years 1004, the earliest record, and 1768 inclusive, there had been 23 eruptions, the intervals varying from 6 to 76 years. Sir W. Hooker in his work on Iceland, writing in 1810, says that the last eruption of lava was in 1766, and that it lasted from the 15th of April to the 7th of September, but that flames unattended with lava appeared in 1771 and 1772, since which period neither fire nor smoke had appeared. Sir George Mackenzie, however, describing his ascent of Hecla in 1810, states that on removing some of the slags at the summit, those below were too hot to be handled, and on placing a thermometer among them it rose to 144° †.

Since the eruption in 1845, the island has been visited by French and German geologists, and we shall no doubt receive ere long a detailed account of their observations. On the 26th of October last, M. Dufrenoy laid before the Academy of Sciences at Paris a letter he had received from M. Descloizeaux, who in company with M. Bunsen had visited Hecla last summer. He mentions a change in the height

* Journal of a Residence in Iceland. † Travels, p. 248.

of the mountain, which seems to indicate a falling in of a portion of the summit. The mountain, he says, is a very regular cone, with a slope of from 25 to 30 degrees; the height of the loftiest part they estimated by barometric measurement at 1400 metres (4593 English feet), but this he says is 157 metres (515 feet) less than former trigonometrical measurements; and although, from some defects in their means of observation, he considers 1400 metres only as an approximate height, he does not think that the error, if there is one, can have amounted to so much as 157, and that therefore there has been a considerable breaking down of the sides of the crater. Sir George Mackenzie describes "the middle peak" of Hecla as forming one side of a hollow, evidently a crater; adding that the whole summit is a ridge of slags, and that the hollows on each side appear to have been so many different vents from which the eruptions have from time to time issued, but that they saw no indications that lava had flowed from the upper part of the mountain*. According to M. Descloizeaux, the crater at the summit is almost circular, with an external talus of scoriæ, having an inclination of from 33 to 35 degrees; thus it is evident the form has changed since the visit of Sir George Mackenzie and his companions, Dr. Holland and Dr. Bright, and it is probable that the higher sides have fallen in, thus accounting for the diminution of height. The exterior part of the cone M. Descloizeaux describes as traversed by fissures containing fumeroles which deposit sulphur; and as the bottom of the crater was covered with *old* snow, it was clear that the eruption of 1845 was not from the main crater, but, like the more recent ones of Etna, from the side of the mountain. On one side M. Descloizeaux observed two craters connected by a very narrow ledge, one of them 600 feet in diameter, and the other half that dimension. He does not give the height from which the eruption took place, but describes the stream of lava that was poured forth to have been directed W.S.W. From the place where it burst forth, to its termination in the plain below, he estimates its length to be 16 kilometres, which is nearly equal to 10 English miles; its greatest breadth at 2 kilometres (about 1¼ mile); and its thickness ranges, he says, from 15 to 25 metres; that is, from 49 to 82 feet. This is an enormous mass, but it is insignificant in comparison with that which flowed from the neighbouring mountain of Skaptár Jokul in 1783; there were then two streams, one 50 miles in length, with a breadth of from 12 to 15 miles, the other 40 miles long and 7 miles broad, both 100 feet in thickness†. But in regard to this stream of 1845, there is an important fact communicated by M. Descloizeaux, viz. that they found the inclination of the stream very variable throughout, "from 0 degree to 25°"—an observation of great interest as regards the theory of the formation of volcanic mountains. He further describes its structure as follows:—"The stream is in no part homogeneous; it consists throughout of isolated blocks, often of very considerable volume, accumulated with a certain degree of symmetry, the congeries resembling an immense ribbon, at the edges of which is a talus, with an inclination between 35 and 40 degrees; and the interior

* Id. page 248.

† Lyell's Principles of Geology, 7th Ed. p. 408.

exhibits a multitude of small longitudinal and parallel ravines, having often a depth of 5 or 6 metres ($16\frac{1}{4}$ to $19\frac{1}{2}$ feet). The centre of the stream still, in July 1846, contained numerous fumeroles in which were beautiful transparent crystals of muriate of ammonia, and large fibrous masses of the same salt, together with a vast quantity of muriate of iron." The rugged surface here described is, as you are aware, a very usual accompaniment of lava streams, arising from the cooling and subsequent cracking by the heat of the inferior fluid mass, and beneath this fissured crust there might be a continuous stream of homogeneous lava, which in cooling would become columnar, and a cross section of the stream would in that case probably exhibit a mass of basaltic pillars, capped by an amorphous layer, and that surmounted by a congeries of blocks, the fissured surface of the stream, just as we see numerous instances in Auvergne, and in many districts where the older trap rocks have flowed in broad streams. M. Elie de Beaumont, in his very elaborate and interesting researches on the structure and origin of Etna, maintains that, in accordance with M. Von Buch's theory of craters of elevation, the beds composing the nucleus of the central mass of Etna have been raised to their present inclination, from a position approaching nearly to horizontality; and appears to be of opinion that no homogeneous stream of lava could consolidate into stone on a surface having an inclination of more than 7 or 8 degrees*. M. Descloizeaux states, as already mentioned, that in some places the stream from Hecla has an inclination of as much as 25 degrees; but if the parts so inclined are composed only of blocks and scoriæ, if underneath there be not a bed of homogeneous lava, that amount of inclination would not be opposed to the theory of M. Elie de Beaumont. We must hope that the detailed descriptions of the French and German observers will throw much light on the structure of this vast expansion of melted stone. I understand that M. Waltershausen is one of those who went from Germany, and his seven years' study of Etna renders him peculiarly qualified to describe the phænomena and compare them with those with which he is so well acquainted.

In the Proceedings of the Royal Academy of Berlin for December 1845, there is an account of a paper read by Professor Ehrenberg, containing the result of a microscopic examination of the dust that fell on the Danish vessel; and in the Proceedings for May last there is a supplement to that paper, describing his examination of some ashes that had been erupted from Hecla on the day above-mentioned. Translations of these notices are given in the last number of the Quarterly Journal of this Society. In these notices, Professor Ehrenberg identifies the dust that fell on the ship with the ashes erupted from Hecla, and they afford another instance of that very remarkable fact, previously made known to us by the same philosopher, viz. the presence of the siliceous shells of infusoria in ashes ejected from volcanos in many different countries. He found thirty-seven different species of these minute organisms, not one of them decidedly new, and all of them peculiar to fresh water. Fifteen are living forms known to exist at present in Iceland.

* Description Géologique de la France, tome iv. p. 176.

There are two obvious conjectures as to their origin: the one is, that surface waters may percolate deep into the earth and penetrate to the volcanic focus, and we know from the celebrated case in South America mentioned by Humboldt, that large masses of subterranean fresh water have been brought within the reach of volcanic force; and the mud, or Moya, which was thrown up from the interior of the earth during the earthquake of Riobamba in 1797, contained siliceous shells of infusoria. The other conjecture is, that old sedimentary beds, containing infusorial remains, lying within the reach of the volcanic force, may have been shivered to atoms, and blown out at the orifice. We know that the shells of species of infusoria that cannot be distinguished from those now living have been found in sedimentary deposits of very old date; and Ehrenberg informs us that infusorial remains have been found in beds of the coal-formation near Dresden.

M. Flourens communicated to the Academy of Sciences on the 16th of November the results of some observations of MM. Descloizeaux and Bunsen last July, on the intermittent boiling springs of the Geyser and *Strockr**, the latter being within 140 yards of the Great Geyser†. The observations were on the temperature of the water, in the great column or well of each, made by suspending thermometers at different depths, at different times before and after eruptions. The Great Geyser has a depth of 22 metres (72 feet), and the experiments showed that the temperature of the column diminished gradually from the bottom upwards, and that the maximum temperature at the bottom before a great eruption was 127°·6 Centigrade (260°½ Fahr.), and the minimum 122° (251°½ Fahr.) after an eruption. The temperature of the water at the surface was 85°·2 (185° Fahr.), when that at the bottom was 127°.

After an eruption, the lowest thermometer stood at 121°·6 (251° Fahr.); nine hours afterwards at 123°·6 (254½° Fahr.). Between 11 o'clock A.M. of the 6th July and 2·55 P.M. of the 7th, there was no eruption, so that there had been an interval of nearly twenty-eight hours; and the water at the latter time, at the bottom, was 127°·6 (261½° Fahr.); a quarter of an hour afterwards there was a slight eruption.

The Strockr is a circular well 44½ feet deep, with an orifice of about 8 feet which rapidly diminishes downwards, and at about 27¼ feet from the surface the orifice is only 10¼ inches. The column of water between the eruptions has a mean depth of 27½ feet, so that its surface, which is in a constant state of ebullition, is generally from 10 to 13 feet below the surface of the ground. The temperature of the water at the bottom varied from 112°·9 to 114°·2 (235° to 237½° Fahr.), and the same temperature continued throughout a depth of about 20 feet, when it began to sink, and at the surface of the water the thermometer stood at 100° (212° Fahr.).

* It is called Strokkus in the Comptes Rendus, but Henderson calls it Strockr, and says the name is derived from the verb "strocka," to agitate, or bring into motion.

† Henderson's Iceland, page 69.

These observations on the temperature of the water are highly curious and important. We have a temperature of 261° of Fahr. at the bottom of a free open column of water, in which thermometers could be suspended on a line dropped from the surface, while it might have been expected that as soon as a film of water at the bottom was raised to a higher temperature, it would ascend, and be replaced by a colder and heavier film, and that thus a constant current would be established throughout the column, until the whole arrived at a temperature of 212°, when ebullition would commence and continue. The pressure of the column of water may perhaps account for the high temperature at the bottom, especially if the free circulation be impeded by the sides of the well not being vertical, and still more by projections in the sides causing contractions of its diameter. But the experiments of M. Donny of the University of Ghent, published in the 17th volume of the Memoirs of the Royal Academy of Sciences and Belles Lettres of Brussels, on the Cohesion of Liquids, may perhaps be considered as throwing some light on this phænomenon of the Geyser. By a series of carefully conducted experiments M. Donny has shown:—

1. That the constancy of the boiling point of water, under the ordinary atmospheric pressure, depends upon its containing a considerable quantity of air;

2. That there is a marked difference between the boiling point of water containing air, and of water freed from air;

3. That a small quantity of air, dissolved in water, is sufficient to attenuate greatly *the cohesion existing between the molecules of the water*;

4. That when water is freed from air, as far as that is possible, the cohesion of the molecules is so increased, that a higher temperature is necessary to overcome it, and that the boiling point is very considerably raised.

M. Donny succeeded in raising the temperature of water so freed of air to 135° Centigrade (equal to 275° of Fahr.), under the ordinary atmospheric pressure, without its exhibiting any symptom of ebullition; showing, that the cohesion of the molecules was nearly equal to the pressure of three atmospheres on water containing air. This is a fact most important to bear in mind in reasoning upon many geological phænomena, particularly those connected with the solution of silica.

The further researches of M. Donny, recorded in the same memoir, appear also to offer an explanation of the violent and intermittent eruptions of the Geyser; for he states that if water deprived of air be exposed to so considerable an increase of temperature as to overcome the force of the cohesion of the molecules, the production of vapour is so instantaneous and so considerable as to cause an explosion. As water long boiled becomes more and more deprived of its air, M. Donny attributes the sudden bursting of the boilers of steam-engines to the same cause.

The Pleistocene (Newer Pliocene) Period.

The Essay of Professor Edward Forbes in the first volume of the Memoirs of the Geological Survey of Great Britain, "On the connexion between the distribution of the existing Fauna and Flora of the British Isles, and the Geological Changes which have affected their area, especially during the epoch of the Northern Drift," is an admirable example of the light to be derived from other branches of natural history in the prosecution of geological inquiries, of the application of animal and vegetable physiology, and a knowledge of the habits and distribution of animals and plants, to the elucidation of very difficult problems in Geology. The memoir is so interesting and attractive throughout, so suggestive of great views, that I am tempted to dwell upon it at some length.

The principal theory which it is the object of this essay to establish is based on the assumption of the existence of *specific centres*, that is, of certain geographical points from which the individuals of each species have been diffused; and their consequent descent from a single progenitor, or from two, according as the sexes might be united or distinct. The author further declares, as his opinion, that "the abandonment of this doctrine would place in a very dubious position all evidence the palæontologist could offer to the geologist, towards the comparison and identification of strata, and the determination of the epoch of their formation." Having assumed the doctrine of specific centres as true, the problem he proposes to solve is, *the origin of the assemblages of the animals and plants now inhabiting the British Islands*. The enumeration of the species and the distribution of our indigenous animals and plants, according to our author, have been worked out by the united labours of many British naturalists, more completely perhaps than those of any other country; but he considers that the history of their respective birth-places or origin is still to be made out. Within the limited area of the British Isles, there are a great number of animals and plants which are not universally dispersed, but are congregated in such a way as to form distinct regions or provinces, which have remained unchanged as long as there are any records. The vegetation presents five well-marked Floras, four of which are restricted to definite provinces, whilst the fifth, besides exclusively claiming a part of the area, overspreads and commingles with all the others.

The author is of opinion that there are only three modes in which an isolated area may become peopled by animals and plants: 1st, by special creation within that area; and there is every reason to believe that that mode had but little influence in determining the vegetation and animal population of the British Isles: 2ndly, by transport to it; and for many reasons he considers that to be an insufficient mode: and 3rdly, *by migration* before the isolation of the area; and this last he believes to have been the mode by which the British Isles have chiefly acquired their existing flora and fauna, terrestrial and marine, and that it took place subsequently to the Miocene epoch. I shall first shortly describe the *Five Floras*.

I. The West Irish Flora.—The mountainous districts of the west and south-west of Ireland are characterized by botanical peculiarities, which depend on the presence of a few prolific species of the families *Saxifrageæ*, *Ericaceæ*, *Lentibulariæ*, and *Cruciferæ*, the high lands in the north of Spain being the nearest point on the Continent where these plants are native, especially in the mountains of the Asturias, and the species are all members of families having seeds not well adapted for being wafted through the air across the sea.

II. The Devon Flora.—In the south-east of Ireland and south-west of England, there is a flora which includes a number of species not elsewhere seen in the British Isles, and which is intimately related to that of the Channel Islands and the neighbouring parts of France; and in the Channel Islands they are associated with a number of plants which are not natives of England or Ireland. In the south-east of Ireland, the number of plants of this Gallican type is greatly diminished, while such as are present are species met with also in the south-west of England. This second flora is accompanied by terrestrial mollusca of the same climatal stamp.

III. The Kentish Flora.—In the south-east of England, the vegetation is distinguished by the presence of a number of species common to this district and the opposite coast of France; and the peculiar character of the entomology and that of the pulmoniferous mollusca, including several species, are intimately connected with this flora. It is evidently derived from the north-western provinces of France.

IV. The Alpine Flora.—The summits of our lofty mountains yield a variety of plants not found elsewhere in the British Islands; the species of them are most numerous on the Scotch mountains; they are comparatively rare on those of Cumberland and Wales, diminishing progressively southwards. These alpine plants are all identical with the plants of more northern ranges, as the Scandinavian Alps, where however there are species associated with them which have not been found in the British Islands. In Ireland also, a few of these alpine or sub-alpine plants of Scandinavian origin are found. The fauna of our mountain regions, so far as it is developed, bears the same relation to more northern countries, and the absence of peculiar pulmonifera is as good evidence, in the opinion of our author, as the presence of Scandinavian forms of insects.

V. The General Flora.—This is everywhere present, alone, or in company with the others—is identical as to species with the flora of Central and Western Europe, and may be properly styled *Germanic*. "Every plant universally distributed in these islands is Germanic; every quadruped common in England, and not ranging to Ireland or Scotland. The great mass of our pulmoniferous mollusca have also come from the same quarter. Certain botanical and zoological peculiarities are presented by the eastern counties of England. In every case we find these to depend on Germanic plants and animals arrested in their range. The number of species of the Germanic type diminishes as we go westwards, and increases when we cross the German Ocean. On the other hand, the peculiarities of the Irish and Scottish faunas and floras depend either on the presence of animals and plants which are not of the Germanic type, or on the absence of English species, which are." There are some species of plants which seem to indicate a derivation from a more northern point in the Germanic region, than that from whence the main parts of the assemblage came.—In describing these five floras, of which the above is a general outline, the author enumerates an extensive series of instances of species in support of his views.

It thus appears, that the chief part, at least, of the British flora has migrated hither from various regions of the continent of Europe nearest to our shores, extending from Scandinavia to Spain; in other words, that, long after the organisms now constituting the living flora and fauna of these islands were called into existence, Great Britain and Ireland were a part of the continent of Europe. The identity of structure of France and England at the Straits of Dover, and for a considerable distance westward, has long been admitted by geologists to be a proof of the former continuity of the two countries, and the remarkable similarity in the structure of the land on both sides of the more western parts of the English Channel leads to a similar conclusion, viz. that France and England were formerly one country, as far west as the extremity of Cornwall. This is rendered more than probable by the evidence of mineral structure, and Professor Forbes, in this essay, confirms that view by botanical and zoological testimony; not however as regards France only, for he stretches the once continuous land so much further west as to unite Ireland with Spain.

We have now to consider the great and important changes in the configuration of the western shores of Northern Europe, at several distant and successive epochs, which this examination of our flora and fauna leads us to infer, and with a high degree of probability. These changes, involving repeated disruptions, subsidences, and elevations of the land, constitute the more strictly geological parts of this essay, and as such I will dwell upon them more fully. And first, with regard to the period within which these events took place.

The creation of the progenitors of the existing flora and fauna of these islands must have taken place, according to our author, subsequently to the close of the Eocene epoch of the tertiary series, and before the commencement of the historical period, or that during which man has been a known inhabitant of the earth. There is abundant evidence, he thinks, that both the flora and fauna of such parts of these islands as were above water during the Eocene period, must have had a climate far warmer than is suitable to their present terrestrial inhabitants; and the great deposits of peat, formed in part of the remains of vast forests, which probably, during the earliest stages of the true historical epoch, covered a great part of the existing area of the British Isles in many places, overlie *fresh-water* marls of the post-tertiary epoch, occupying depressions in pleistocene marine deposits; and he goes on to prove that it was during the post-tertiary epoch that the migration of *the general* *flora*, that is, the most modern of the five floras, must have taken place.

I shall now endeavour to trace, in succession, the alterations in the configuration of the land connected with each of the distinct floras; geological changes, be it remembered, of a very modern date in comparison with the elevations, subsidences, fractures and contortions which produced the phænomena exhibited by the older formations.

The First, or West Irish Flora.—The author believes that during the deposition of the Miocene tertiaries, a sea, probably shallow, inhabited by an assemblage, almost uniform, of marine animals, extended throughout the Mediterranean region, across the south of France, along the west of Spain, and stretched beyond the Azores. He founds this belief on the uniform zoological character of this sea, from personal examination of Miocene fossils. He believes, that at the close of the period, the whole of the bed of this Miocene sea was pretty uniformly elevated in the region of the Central Mediterranean and West of Europe. He then enunciates a new and somewhat startling opinion, viz. that "a great Miocene land,*" bearing the peculiar flora and fauna of the type now known as Mediterranean, extended far into the Atlantic, past the Azores; and calling up botanical evidence in support of his views, he states that the western boundary of this land, formed by deposits in the sea during the Miocene period, but then an upheaved continent, is now marked by the great semicircular belt of Gulf-weed, ranging between the 15th and 45th degrees of north latitude, and constant in its place. He adduces in support of this bold hypothesis, the testimony of Dr. Harvey (whom he designates as one of the first of living authorities in marine botany) as to the nature of the Gulf-weed, the *Sargassum bacciferum*, who considers it an abnormal variety of the *Sargassum vulgare*, an opinion assented to by Dr. Joseph Hooker, who has had great opportunities of studying the Gulf-weed. Now the *Sargassum vulgare*, Professor Forbes says, is essentially a coast-line plant, growing on rocks with a very limited vertical range; and he believes that the progenitor of the Gulf-weed was attached to the shores of the post-Miocene continent, and that its present abnormal condition is to be ascribed to the submergence of that ancient line of coast. "The fact that there is a well-marked belt of Miocene coast-line in North America, (as shown by Mr. Lyell,) and that the mollusca of that belt indicate a representative, not identical, fauna in that region,

* This term "a Miocene land" is equivocal, and is calculated to convey an erroneous idea of the author's meaning. It would have been more correctly given if he had said, a land consisting of rocks formed during the Miocene period, and subsequently upheaved above the surface of the sea. There is a similarly ambiguous expression used in a subsequent passage, where the author speaks of "a belt of Miocene coast-line in North America," meaning a coast-line of rocks formed under the sea during the Miocene period. A "Miocene land," in correct geological language, means land that existed during the Miocene period, on which the land animals and plants then existing lived, and which bounded the sea and freshwater lakes in which the aquatic animals and plants of that period lived; and such land might consist of rocks of any, and of several, antecedent epochs.

proves that during the Miocene period there was an Atlantic gulf separating the new world from the old, and favours the notion that the coast-line of a post-Miocene European land would be somewhere in the central Atlantic, about the position of the great Fucus bank. The probability of the existence of such a land is further borne out by the fact, that the floras of the groups of islands between the Gulf-weed bank and the mainland of the old world are all members of *one* flora, itself a member of the *Mediterranean* type. In the Madeira group, the Canaries, Cape de Verde islands, and other East Atlantic islands, there are marine tertiary strata, apparently of Miocene age, probably parts of one system of land that was once continuous, for their botanical and zoological characters agree as part of one province. Their floras are all closely related to those of the nearest mainland, and are also mutually related, through endemic plants, to each other. We learn from Humboldt, that Madeira and Teneriffe contain plants in common with Portugal, Spain, the Azores, and the north-west coast of Africa.

Nothing certainly can mark more strongly than this instance, how, in our endeavours to trace the past history of our earth, a new light may dawn in a quarter the least expected ; for certainly nothing *à priori* seemed more improbable, than that an examination of the botanical nature of the floating Gulf-weed should suggest the possible extension in former ages of the continent of Europe into the middle of the Atlantic. The author himself designates his hypothesis as a startling one ; and from its novelty and boldness it may perhaps be so characterized. It is true, that between the Gulf-weed and the shores of Europe and Africa that are opposite to it, there is a great depth of water, not less than 700 fathoms, or 4200 feet, as I am informed by a high authority; but that cannot be considered by the geologist as a valid objection. There are beds of the Miocene epoch at a height of 6000 feet above the sea-level in the Lycian Taurus, and the bed of the sea must therefore have been elevated not only to that amount, but to whatever more must be added for the depth of sea in which the beds were deposited. If at all periods there have been elevatory movements, there is no improbability in supposing subsidences of equal amount to have occurred. Mr. Darwin has shown, in the recent work to which I have referred, that, during a modern part of the secondary period, there must have been a subsidence, in mass, to the amount of several thousand feet of the greater part of the continent of South America, a subsequent elevation, and again subsidence ; so that neither in point of extent of area moved, nor of depth of subsidence, is the hypothesis of Professor Forbes unsupported by proofs of similar movements in other parts of the world.

It is thus to a period subsequent to the close of the Miocene epoch, and after the deposits formed in the sea of that epoch had been raised up to form dry land, that our author traces the origin of what he considers the most ancient part of our island flora, that represented by the relics of it on the western coast of Ireland, an assemblage of plants small as to number of species, but most of them playing an important part in the mountain vegetation of the region, and they are all species which at present are forms either peculiar to or abundant in the mountains of Spain and Portugal, and especially in the Asturias. At this period, he believes Ireland and Spain were united, and that the plants in question extended over land, which then occupied that part of the ocean that lies between the Asturias and the west of Ireland, but which flora he supposes to have been afterwards during the glacial epoch isolated, and in great part destroyed; such species as survived being the most hardy and able to bear the lowered temperature.

The Second, or Devon Flora.—The great extent of land, formed, in part at least, of the elevated bed of the Miocene sea, was destined to give way again to the return of the ocean, either by subsidence or denudation, probably by both causes, leaving many evidences however of its former existence. The destruction of this land the author conceives to have been in progress during the deposition of the beds of the Pliocene epoch, but that the opening up of the English Channel had only begun, and towards the west; for this flora, exhibiting features of transition between the great flora of Central Europe and that of the Southern or Mediterranean region, had its origin, he believes, in that part of France included in the ancient provinces of Brittany and Normandy.

The Third, or Kentish Flora.—The condition of things our author believes to have undergone little change from what they were during the passage of the Devon Flora, while the migration of this flora was in progress, unless, perhaps, a still further scooping out of the English Channel from the west.

The Fourth, or Alpine Flora.—A very considerable change occurred about this time. A great subsidence must have taken place, so as entirely to change the relative proportion of sea and land, and which must have been very different in the region now under consideration from that which at present exists. A great part of the British Isles the author believes to have been then covered by the sea, so that our mountains were comparatively low islands. If we extend, he says, a line from the coast of Norfolk westward across Ireland, and eastward so as to strike against the Ural chain, all north of that line he believes to have been at this epoch under the sea; that is, the whole of central and northern Europe, bounded by land, since greatly uplifted, which then presented to the water's edge those climatal conditions for which a sub-arctic flora destined to become alpine was specially organized. This, he says, was the sea of the *Glacial period*, when the climate of the whole of the northern and part of central Europe was far colder than it is now. It exhibited conditions, physical and zoological, similar, indeed nearly identical, to those now to be met with on the north-eastern coasts of America, within the line of summer floating ice. It was during this epoch, he believes, that Scotland and Wales, and part of Ireland, then groups of islands in this ice-bound sea, received their alpine flora, and a small portion of their fauna. The period of time that elapsed while the sea covered the region above described, he terms *The Glacial Epoch*, using that term to express the ice-charged condition of that sea, and the prevalence of severe climatal conditions throughout a great part of the northern hemisphere,—conditions which probably, he thinks, did not prevail during its earlier stage, and the gradual disappearance of which marked its close.

The remains of the marine animals found in the strata deposited in this sea prove its glacial or arctic character. Remnants of that ancient sea-bottom, stratified and unstratified masses of clay, sand and gravel, often of great thickness, more than a hundred feet, and great superficial extent, are to be met with in many parts of Great Britain and Ireland. These beds when carefully examined are found to contain in many places fossil marine testacea, usually scattered, rolled, and broken, but in particular localities entire and undisturbed, presenting undoubted evidence of the animals they inclosed having lived and died on the spot. About 124 species of Mollusca have been found in these beds in the British Isles, and, with few exceptions, they are all forms now existing in the British seas, but indicating a state of climate colder than that prevailing in the same area at present; and among them are species now known as living only in European seas north of Britain, or in the seas of Greenland and Boreal America. The prevalence of these forms, indicating a lower temperature in the testacea of the British glacial deposits, cannot be ascribed to their having lived in greater depths; for as far as our author has seen, there is no British case of an upheaved stratum of the glacial formation containing organic remains, evidently untransported, which may not have been formed at a less depth than 25 fathoms, and it is probable that between 10 and 15 fathoms would more frequently approach the truth. Further, there is abundant evidence that over a great part of the area occupied by these glacial beds, the uppermost portions, composed of sand and gravel, contain fossils belonging to littoral species, and indicating a much less depth of water than existed previously, during the deposition of the inferior marls.

The deposition of the beds in the glacial sea, the author considers to have been synchronic with that of the newer pliocene beds in the tertiary deposits of Sicily, Rhodes, and other parts of the Mediterranean basin; and from the existence of certain species of shells in these beds, characteristic of the southern bounds of the glacial beds in Britain, he infers that during the newer pliocene, or pleistocene epoch, there was a communication open between the Mediterranean and Northern seas. He also infers from a great amount of varied and concurrent zoological evidence, that during the glacial period, land existed in high northern latitudes, that either united or brought into very close approximation the continents of Europe and North America. There could not then have been, he says, such a separating abyss between Northern Europe and Boreal America as now divides them; the sea, through a great part, must have been a shallow sea, and somewhere, probably far to the north, there must have been either a connexion or such a proximity of land as would account for the transmission of a non-migratory terrestrial, and a littoral marine fauna.

There is in this part of this ingenious essay, a want of that clear statement of the author's views as to the mode of migration of the alpine flora, which we find when he treats of that of the other floras. He tells us that the plants of this flora could not have been inhabitants of the ancient west of Europe, but of Scandinavia. "The alpine floras of Europe and Asia," he says, "so far as they are identical with the floras of the Arctic and Sub-Arctic zones of the old world, are fragments of a flora which was diffused from the north, either by means of transport not now in action on the temperate coasts of Europe, or over continuous land which no longer exists." But he had already stated, that during the glacial epoch, when Scotland and Wales, and part of Ireland, received their alpine flora and a small portion of their fauna, they were groups of islands in an ice-bound sea; and that in an after-state of things these islands were upheaved and converted into mountains, and the plants of the colder epoch survived only on the mountain regions which had been so elevated as to retain climatal conditions similar to those which existed when those regions were low ridges or islands in the glacial sea. Thus the only modes of migration, according to this view of a group of islands, must have been by currents or by the transporting agency of icebergs; and from what he states (p. 351), in speaking of the origin of the alpine floras of the Alps and Carpathians, and some other mountain ranges, it is evident that, though not directly expressed, an iceberg is the mode of transport that is chiefly in the author's mind in that part of his essay. Icebergs have been seen partially covered with alluvial soil, on which plants were growing. Are we therefore to suppose, that the alpine flora was transferred from the land now called Scandinavia to that now called Britain, by such icebergs as chanced to carry plants with soil sufficient to preserve their vitality, and as chanced to be stranded on the islands? This mode of transmission appears to have been felt to be unsatisfactory and inadequate by the author, for towards the conclusion of the essay we find the following passage:—"The phænomena of the glacial formations, the peculiarities in the distribution of the animals of that epoch, and in the relations of the existing fauna and flora of Greenland, Iceland, and Northern Europe, are such as strongly to impress upon my mind, that the close of the glacial epoch was marked by the gradual submergence of some great northern land, along the coasts of which the *littoral* mollusks, aided by favouring currents, migrated, whilst a common flora became diffused over its hills and plains. Although I have made icebergs and ice-floes the chief agents in the transportation of an Arctic flora southwards, I cannot but think that so complete a transmission of that flora as we find in the Scottish mountains was aided perhaps mainly by land to the north, now submerged." I am inclined to the opinion, that this last view of the author, the former existence of land towards the north pole, from which there was a continuous communication with the land of our island, is the more probable hypothesis; and many phænomena of the northern drift, especially the difficulty of conceiving any other source for the origin of the vast mass of detrital matter, water-worn stones and boulders, which are found in the northern drift that do not belong to the rocks that lie immediately beneath it, but must have come from a distance, all point to the former existence of northern land now submerged. If during the existence of the glacial sea, "it was the epoch of glaciers and icebergs, of boulders and groovings," there must have been a mountainous northern land with deep valleys in which the glaciers could be formed, and terminating in the sea, so that icebergs could be detached; the mountains supplying the fragments of rock that were rounded into boulders and ground into gravel, sand and mud, and also the fragments fixed in the icebergs which caused the groovings. How otherwise can we suppose the cold of the glacial epoch to have been created, except by the existence of a continent of greatly elevated land in high northern latitudes? Can we suppose the existing land of Norway and Sweden adequate to produce such effects?

The Fifth, or General Flora.—At the close of the glacial period, our author believes another great change to have taken place; that the bed of the glacial sea was gradually upheaved, and along with it the islands that were scattered in that sea, the elementary parts of the future Britain and Ireland, so that continuous land arose where sea had been before and where sea again is, the area of the present German Ocean forming then extensive plains over which the great mass of the existing flora and fauna of the British Isles migrated from the Germanic region of the continent. How far northwards this land extended it is now impossible to say, but we find fragments of it bordering the seaside, even to the farthest parts of the mainland of Scotland. It linked Britain with Germany and Denmark, and a corresponding plain united Ireland with England. As a great part of the area, previously occupied by water, now became land, the banishment of a number of species necessarily took place, many of which, in consequence of the change of conditions arising from the causes of their expulsion, retired for ever.

In the 'History of British Fossil Mammals and Birds' by Professor Owen, to the recent publication of which I briefly referred in my address of last year, we have the full expression of his belief of the irresistible demonstration afforded by the fossil remains which form the subject of that valuable work, that during the period now under consideration Great Britain and Ireland formed continuous land with France. He informs us, that in his endeavour to trace the origin of our existing mammalia, he has been led to view them as descendants of a fraction of a peculiar and extensive mammalian fauna which overspread Europe and Asia, at a period geologically recent, yet incalculably remote and long anterior to any evidence or record of the human race: that the fact of the Pliocene Fossil Mammalia of England being almost as rich in generic and specific forms as those of Europe, leads to the inference that the intersecting branch of the ocean which now divides this island from the continent did not then exist, as a barrier to the migration of the Mastodons, Mammoths, Hippopotamuses, Rhinoceroses, Bisons, Oxen, Horses, Tigers, Hyænas, Bears, &c., which have left such abundant traces of their former existence in the superficial deposits and caves of Great Britain: that the idea of a separate creation of the same series of Mammalia in and for a small contiguous island cannot be entertained; and that the idea of their having swum across a tidal current of sea twenty miles in breadth is equally inadmissible.

I have thus endeavoured to trace the successive geological changes, the upheavals and subsidences of the land, which by strong evidence, botanical and zoological, have been shown to have occurred in this western part of Europe during the more modern of the tertiary periods. But we have not yet traced the more recent changes which Professor Forbes points out in this essay, up to the historical period. We have seen that most of our existing plants and animals can boast a direct lineal descent from ancestors that flourished long before man set foot on these islands, probably before the creation of the human race; certainly before the formation of the German Ocean, or the English and Irish Channels. These seas have great inequalities of depth, but in some places the soundings are as much as nearly 100 fathoms. They were probably formed by the double and concurrent operation of subsidences of the land, and by the wearing action of tides and waves on other parts of the land, cracked, fractured, and loosened as it probably would be by these subsidences. We know that the sea has worn away large tracts of land within our own experience, and that lands on which forests of existing trees grew, have subsided below the level of the sea, on many parts of our coasts. "The formation of the German Ocean and Irish Sea, and new lines of coast, events calling new influences into play, introduced the existing population of our seas. Part of our glacial testacea had been extinguished, part retired to more congenial arctic seas, and a few disappeared from the coasts of Europe, while they continued inhabitants of the shores of America. A considerable number, however, returned to the seas of their ancestors, where they became and remain the associates of numerous forms, some newly called into being to people the new-formed seas, some coming with favouring currents from the warmer seas of the south. Among the latter were a number of forms which had not always been strangers to the British seas. During the genial times preceding the glacial epoch, more than fifty species of testacea, inhabitants at present of our seas, lived in them whilst the Crag beds were in process of formation, but disappeared under the chilly influences of the sub-arctic epoch which succeeded."

On this post-pliocene plain, this upheaved bed of the glacial sea, there must have existed extensive freshwater lakes, from the relics we find of them. In Ireland and the Isle of Man, there are numerous basins of freshwater marls resting on depressions of the upheaved glacial sea-bed, containing shells of existing testacea, along with entire skeletons and many detached bones and horns of the extinct gigantic Irish Elk, the *Megaceros Hibernicus*, which in the opinion of Professor Owen was the contemporary in our islands of the Rhinoceros, Mammoth, and other extinct mammalia, during the period of the formation of the newest tertiary freshwater fossiliferous strata. These freshwater marls are overlaid by peat with its included ancient forests, so that the time when the Megaceros lived was anterior to that of the forests which aided in the formation of the great peat bogs. The land that contained these lakes and supported these extinct animals was in great part worn away between England and Ireland, as it was between Germany and England, during the comparatively modern geological epoch, in all probability by the same destructive forces. That subsidence was one cause may be legitimately inferred, for we have abundant proof in the raised beaches on our shores, that the land was subject to the action of internal forces; and masses of the post-pliocene plain of great extent and thickness are found on the western shores of Britain, in the Isle of Man, and in Ireland.

The theory which it is the object of this essay to establish, is founded, as I have already said, upon the assumption of "the existence of specific centres, that is, of certain geographical points from which the individuals of each species have been diffused." It is further established upon the proofs, derived from various sources, of great and repeated changes in the physical geography of the western and north-western parts of Europe, that is, upon the existence in former ages of land where there is now sea, and of sea where there is now land, causing great changes of climate in these regions. The former existence of a warmer climate in northern latitudes had long been made manifest by the zoological and botanical evidence supplied by fossil organic remains; but the 'Principles of Geology' of Mr. Lyell, published in 1830, first taught geologists that it is not necessary to have recourse to extraordinary causes, to account for the former existence, in northern regions, of animals and plants that can live only in the heat of the tropics, for the extremes of climate are confined within a very limited thermometric range. He showed that such a range may be produced by differences in the relative proportions of sea and land, when taken in conjunction with considerations of latitude and of the elevation of the land above the sea-level, and that what we call an arctic climate, a temperate climate, and a tropical climate might alternately prevail in the same latitude, according as the relative proportions of sea and land, and the extent and elevation of the latter, were favourable to the one condition or the other. This fundamental doctrine is now embraced, I believe, by the greater proportion of our geologists, perhaps universally so, in this country at least. By no one, as I have reason to know, is it adopted more unreservedly than by the author of this essay; and on my remarking to him that I missed in his essay a recognition of that important doctrine, which I have always been in the habit of considering as one of the most original and important parts of Mr. Lyell's work now referred to, he replied, that believing the doctrine to be so generally known and adopted, he deemed it unnecessary to refer especially to it, and that he considers his essay in a great measure as a contribution towards the confirmation of Mr. Lyell's climatal views.

To Mr. Lyell we are also indebted for having several years ago called the attention of geologists, not only to the effects of physical conditions arising from changes in the earth's structure, on the existence, distribution and extinction of species, but also to the great changes that have taken place in the land, in many places, since the creation of species now living. Thus in chapter 11 of the first edition of the second volume of the 'Principles of Geology,' published in 1832, we find the following passages:—"We have pointed out in the preceding chapters the strict dependence of each species of animal and plant on certain physical conditions in the state of the earth's surface, and on the number and attributes of other organic beings inhabiting the same region. We have also endeavoured to show that all these conditions are in a state of continual fluctuation, the igneous and aqueous agents remodelling, from time to time, the physical geography of the globe, and the migrations of species causing new relations to spring up successively between different organic beings." "As considerable modifications in the relative levels of land and sea have taken place in certain regions since the existing species were in being, we can feel no surprise that the zoologist and botanist have hitherto found it difficult to refer the geographical distribution of species to any clear and determinate principles, since they have usually speculated on the phænomena, upon the assumption that the physical geography of the globe had undergone no material alteration since the introduction of the species now living *." In the 9th chapter of the third volume of the same work, published in 1833, the following observations occur at p. 115. Treating of *the migration of animals and plants*, he says, "A large portion of Sicily has been converted from sea to land since the Mediterranean was peopled with the living species of testacea and zoophytes. The newly emerged surface, therefore, must, during this modern zoological epoch, have been inhabited for the first time with the terrestrial plants and animals which now abound in Sicily. It is fair to infer, that the existing terrestrial species are, for the most part, of as high antiquity as the marine; and if this be the case, a large proportion of the plants and animals, now found in the tertiary districts in Sicily, must have inhabited the earth before the newer pliocene strata were raised above the waters. The plants of the flora of Sicily are common, almost without exception, to Italy or Africa, or some of the countries surrounding the Mediterranean, so that we may suppose the greater part of them to have migrated from pre-existing lands, just as the plants and animals of the Phlegræan fields have colonized Monte Nuovo, since that mountain was thrown up in the sixteenth century. We are brought, therefore, to admit the curious result, that the flora and fauna of the Val di Noto, and some other mountainous regions of Sicily, are of higher antiquity than the country itself, having not only flourished before the lands were raised from the deep, but even before they were deposited beneath the waters."

We have seen that the great geological conditions to which Professor Forbes refers are—1st, the existence of land above the waters during the Miocene epoch, and of sea between the northern coast of Spain and the British Islands; 2ndly, the formation of deposits in that Miocene sea, and the subsequent elevation of that sea-bottom above the waters, extending over the whole Mediterranean region, and

* Pages 182 and 183.

stretching out into the Atlantic as far as the region of the Gulf-weed, and uniting Spain and Ireland; 3rdly, the destruction of the whole of that vast continent of upraised miocene deposits, with the exception of those comparatively small fragments which remain as evidence that such marine deposits were formed at that period; 4thly, the state of Great Britain and Ireland when they consisted of a group of small islands, the summits of our present mountains, surrounded by a glacial sea; 5thly, the elevation of the bed of that glacial sea, when the smaller islands rising above the surface of the water formed a continuous land of Great Britain and Ireland, connected with the continent, a plain existing where there is now the German Ocean; and 6thly, the disappearance of that Germanic plain, and the formation of the German Ocean, the English Channel, and the Irish Sea.

The agency by which these great changes were effected, is a subject on which the author does not enter. There is one passage which, without explanation, would be quite at variance with a fundamental part of his theory, for at p. 400 he states, "The floras of the islands of the Atlantic region, between the Gulf-weed bank and the old world, are fragments of the Great Mediterranean flora, anciently diffused over a land constituted out of the upheaved *and never again submerged* bed of the (shallow) Miocene sea." The author, since the publication of his essay, has stated to me in conversation that the words "never again submerged" were intended to apply only to those miocene deposits which are now above the sea-level, which have always remained above the sea-level since the time of their first elevation, as they are nowhere capped by marine deposits of a later epoch.

The disappearance of the supposed land between Ireland and Spain, which he tells us was composed of the upheaved bed of the Miocene sea, as well as that of the whole of his supposed vast continent of the same deposits, could only have been effected by subsidence. Professor Forbes is, I know, disposed to ascribe a great deal to the action of denudation, and the wearing away of land by the action of the sea, both where the waves beat upon shores, and where currents far below the surface have destructive powers. Without denying the known powerful action of the former force, nor the possible power of the latter, but of which we do not as yet know much for certain, it is contrary to all probability,—it may almost be said to be physically impossible,—that such an agency could produce the effects. For how stands the case? Without referring to the supposed land between the region of the Gulf-weed and the old world, let us take that portion only which the author believes to have united Ireland with the north of Spain, and specially with the province of Asturias. The distance is about 560 miles. Now all along the north coast of Spain from Bayonne to Cape Ortegal, there is very deep water near the shore. There is a depth of 80 fathoms within six miles of the land, and it is stated in the French Admiralty Chart, published in 1832, that within twenty-five miles of the land of the Asturias, there were soundings of 220 fathoms without finding the bottom; and the same depth was found at a distance of 280 miles.

From that point there is a shallowing of the water towards Ireland to 100, 80, and 67 fathoms, and within ten miles of Cape Clear there is still a depth of 54 fathoms. A denudation to such depths is inconceivable, but a subsidence not only to that but to much greater depths is perfectly conceivable. If, as is probable, the subsidence was gradual, then the action of the waves and of currents, for a short time at least, would come into play, while the water was still comparatively shallow, especially if the subsidence was accompanied by earthquakes or other internal forces, causing fissures and otherwise breaking up and loosening the land. Professor Forbes is of opinion, that all the operations which brought about a change of climatal conditions were gradual. He states (p. 401) that "all the changes before, during, and after the glacial epoch appear to have been gradual and not sudden, so that no marked line of demarcation can be drawn between the creatures inhabiting the same element and the same locality during two proximate periods." We may also infer that subsidence was the chief cause of the formation of the English Channel, St. George's Channel, and the German Ocean. At the entrance of the English Channel, there is a depth of from 56 to 70 fathoms, and the mid-channel shallows from thence to 28 fathoms off Beechy Head. In the distance from Dungeness to Dover, and from Boulogne to Calais, the sea-bottom is very uneven, the depth of water varying from 10 to 30 fathoms. The great inequalities in the sea-bottom, over all the region under review, are of themselves a strong argument in favour of subsidence, for it is infinitely more probable that subsidences would be unequal, than that any denuding force would produce such effects. At the south entrance of St. George's Channel there is a depth of 60 fathoms, and between Waterford and St. David's Head the soundings are from 38 to 54 fathoms. Between Dublin and Belfast Lough the soundings from the shore to the mid-channel between Ireland and the Isle of Man are from 20 to 74 fathoms, and opposite the coast of Galloway they deepen to 99 fathoms. In the German Ocean and North Sea the depths are in general not so great; but here too there are great inequalities, the soundings varying from 9 fathoms, within four miles of the shore, to as much as 76 fathoms in some places, the shallowest parts being over the extensive banks that prevail in that ocean, such as the Long Forties, the Long Bank, the Dogger Bank, and the little Fisher's Bank off the coast of Scotland. Our author's theory twice supposes the upheaval of the sea-bottom into land, viz. that of the Miocene and that of the Glacial sea, and subsidences are equally conceivable.

The most extensively continuous tertiary deposit with which we are acquainted, is that of pleistocene age on the eastern side of the southern half of the continent of South America, extending more than 1600 miles northward from Tierra del Fuego, and consisting of the great covering of gravel spread over Patagonia, and of the calcareo-argillaceous deposit that constitutes the soil of the Pampas. Much as we are indebted to M. Alcide d'Orbigny for the great additions to our knowledge of the geology of South America, contained in his account of his long residence and widely-extended observations in that country, the recent work of Mr. Darwin contains a more detailed and elaborate description, a more critical examination, if I may so express it, of the nature and probable origin of these modern tertiary formations, than any we have yet had.

The Pampean formation is throughout of a very uniform character, consisting of a reddish, slightly indurated earth or mud, often, but not always, including, in horizontal lines, calcareo-argillaceous concretions or marl. Except in a few detached localities, it is unmixed with gravel, and the traveller may pass over many hundred miles of level surface without meeting with a single pebble, or discovering any change in the nature of the soil. These marly concretions often unite into irregular strata, and over very large tracts of country the entire mass consists of a hard, but generally cavernous marly rock, resembling the less pure freshwater limestones of Europe, and called by the inhabitants *Tosca rock*. A microscopic examination has disclosed in it fragments of shells and corals ; and Professor Ehrenberg, having examined specimens of it from different localities, discovered twenty different forms of infusoria, the greater proportion being of freshwater origin, but five identical with such as are found in brackish water. It is remarkable that, except in some detached localities near the coast, the Pampean deposit is almost entirely devoid of shells, either marine, fluviatile, or land. Mr. Darwin states, that with the exception of the *Azara labiata*, a living estuary shell, occasionally, but rarely found, and sometimes imbedded in the tosca rock, this formation, within the true limits of the Pampas, although of such vast extent, affords, as far as he knows, no instance of the presence of shells. It exhibits here and there changes of colour, indicating regular lines of stratification, always horizontal; and although it has been subjected to great and powerful elevatory forces, it nowhere exhibits any irregular movements, nor is there any appearance of much superficial denudation.

It extends, uninterruptedly, nearly 800 miles from N. to S., and about 400 miles from E. to W. In depth it varies from 30 to 100 feet. A range of mountains, attaining a height of 3340 feet, rises in the midst of the plain near the Rio Colorado, the Sierra Ventana, and the Pampean deposit comes up nearly horizontally to the northern and southern foot of these mountains, insinuating itself between the parallel ranges, at a height, in this place, of 840 feet above the sea, indicating an upward movement of the land in mass. The high plain round this range sinks quite insensibly to the eye on all sides. Mr. Darwin states that "round the Sierras Tapalguen, Guitru-gueyu, and between the latter and the Ventana, the tosca rock forms low, flat-topped, cliff-bounded hills, higher than the surrounding plains of similar composition. From the horizontal stratification, and from the appearance of the broken cliffs, the greater height of the Pampean formation round these primary hills ought not to be altogether or in chief part attributed to these several points having been uplifted more energetically than the surrounding country, out to the argillo-calcareous mud having collected round them, when they existed as islets or submarine rocks, at a greater height than the bottom of the adjoining open sea; the cliffs having been subsequently worn during the elevation of the whole country in mass*."

The most remarkable feature to the geologist, of this great Pampean formation, is the vast accumulation of the fossil remains of mammalia which it contains, chiefly herbivorous, generally of great size, and belonging to extinct genera, some even to extinct families or orders,—the Megatherium, Mylodon, Toxodon, Glyptodon, Scelidotherium, Macrauchenia, Megalonyx and Mastodon. "The greater number of them," Mr. Owen tells us, "are referable to the order which Cuvier has called *Edentata,* and belong to that subdivision of the order which is characterized by having perfect and sometimes complex molar teeth, and an external osseous and tessellated coat of mail. The Megatherium is the giant of this tribe†."

Mr. Darwin has given many interesting descriptions of the localities where these fossil bones have hitherto been found; they are all between the 31st and 50th degrees of south latitude; and numerous though the remains already discovered have been, they can form only a very small portion of what lie buried in the deposit; for they have as yet been almost exclusively found in the cliffs and steep banks of rivers. "I am firmly convinced," Mr. Darwin says, "that a deep trench could not be cut in any line across the Pampas without intersecting the remains of some quadruped." The bones occur at all depths, from the top to the bottom of the deposit; he himself found some close to the surface; near Buenos Ayres a skeleton was disinterred from a depth of 60 feet, and on the Parana two skeletons of the Mastodon were found only five or six feet above the base of the deposit.

The theory of the formation of this vast extent of indurated mud and calcareous concretions proposed by M. Alcide d'Orbigny in his 'Travels in South America,' viz. that it was produced by a vast and sudden flood,—a debacle, is shown by Mr. Darwin to be inconsistent with the various phænomena which the deposit exhibits; its structure, its concretions, the horizontal layers of tosca rock, the absence of granite and boulders, all indicating a slow and tranquil deposition,—to say nothing of the improbability of the existence of a mass of fine mud combined with carbonate of lime in a state fit for chemical segregation, ready to be transported by the debacle, and sufficient in amount to cover a space larger than the whole of France. The theory which Mr. Darwin himself suggests appears a very intelligible and probable explanation of the facts he describes. He supposes that the materials of the Pampean formation were derived from the great area of older rocks, igneous and sedimentary, in Brazil and the high country to the north and west that surrounds the plains; that they were transported by numerous streams and rivers and deposited in a vast bay, the former estuary of the Plata, extending into the low country of Banda Oriental and forming a part of the adjoining sea, in the same manner as we have seen that the delta of the Mississippi has been formed. This operation of transport, and deposit of similar materials, ap-

* Page 79. † Owen, Fossil Mammalia, Voyage of the Beagle, p. 15.

pear to have been going on in a much earlier period, for he observed extensive beds of sediment undistinguishable from the Pampas deposit underlying old tertiary rocks on which the true Pampean formation rests. He further supposes, that the bottom of that sea and estuary was gradually rising during the slow progress of the deposition, and that the animals, whose remains are buried, lived on the adjoining land, and that when either dying a natural death, or drowned by inundations, their bodies were floated off to sink in the mud, and be entombed near the spots where they had lived; for not only are entire skeletons found, but even when the bones are separated, they are often met with lying in their proper relative positions, and they never bear the marks of having been worn by attrition in a transport by floods from a distant region.

With regard to the age of the Pampean formation, it appears from the uniformity in its composition, the specific identity of the mammiferous remains over its vast area, and their occurrence throughout its whole depth, that it belongs to one geological epoch; and that from its association with shells now living in the adjoining sea, from the many proofs that the bodies of the animals were imbedded in a fresh state, and that they therefore had co-existed with the shells, it must be of the pleistocene æra. "I feel little doubt," says Mr. Darwin, "that the extinction of the large quadrupeds did not take place until the time when the sea was peopled with all, or nearly all, its present inhabitants*."

From the southern termination of the Pampean deposit at the Rio Colorado, another vast area of detrital matter, very different in its nature, but chiefly of the same age, commences; for nearly the whole of Patagonia is covered with gravel, capped by a thin irregular bed of sandy earth, and it extends across the Straits of Magellan into Tierra del Fuego. Near the coast it is generally from 10 to 30 feet in thickness, but at a distance of 110 miles inland it has a depth of 212 feet, and Mr. Darwin is of opinion that its average depth may be not less than 50 feet. It covers an area in Patagonia of 630 by 200 miles, rising from the coast to the foot of the Cordillera, a height of between 3200 and 3300 feet. Porphyries of different kinds constitute the chief mass, but there are also pebbles of other crystalline felspathic rocks, basalts, compact clay-slate and quartzose schists, all derived from the mountainous country on the west, and from the basaltic dykes or streams that occur in different parts of the inclined plane near these mountains. The absence of angular fragments, and the perfectly rounded condition of the pebbles, indicate long-continued attrition. The rarity and inconsiderable size of the streams in Patagonia make the transport and wearing by river-action improbable; "moreover," the author adds, "in the case of the one great and rapid river of Santa Cruz, we have good evidence that its transporting power is very trifling. This river is from 200 to 300 yards in width, about 17 feet deep in its middle, and runs with a singular degree of uniformity five knots an hour, with no lakes, and scarcely any still reaches: nevertheless, to give one instance of its small transporting

* Introduction to Professor Owen's 'Description of the Fossil Mammalia collected by Mr. Darwin.'

power, upon careful examination, pebbles of compact basalt could not be found in the bed of the river at a greater distance than ten miles below the point where the stream rushes over the debris of the great basaltic cliffs forming its shores: fragments of the cellular varieties have been washed down twice or thrice as far." Mr. Darwin is of opinion, that the cause of the rounding of the fragments and the spreading out and levelling of the gravel is to be ascribed to the action of the sea, as it gradually receded from the foot of the Cordillera to the present coast, by the slow upheaval of the land. He admits, however, that it is a problem of great difficulty. "By whatever means," he says, "the gravel formation of Patagonia may have been distributed, the vastness of its area, its thickness, its superficial position, its recent origin, and the great degree of similarity in the nature of its pebbles,—all appear to me well-deserving the attention of geologists, in relation to the origin of the widely-spread beds of conglomerate belonging to past epochs*." It is seen on the coast to rest on horizontal beds of older tertiary strata, which in some places form cliffs from 800 to 900 feet in height: as it is seen in the interior capping terraces formed of deposits containing shells, and as the gravel with its sandy covering is often strewed with recent marine shells, there is no doubt of its belonging, like the Pampean formation, to the pleistocene age; and in all probability they were nearly contemporaneous. In the valley of Santa Cruz, at a distance of 100 miles from the sea, and at an elevation of 1400 feet, the gravel is covered with numerous angular erratic blocks, some as much as 60 feet in circumference. These were described by Mr. Darwin in a paper read in this room, and published in the sixth volume of our Transactions, and he there attributes their position to the transporting action of icebergs, the probable origin of the erratic blocks of Northern Europe.

Elevation of the land.—We know that the land of the western coast of South America has risen considerably in our own time: we have proofs of considerable elevations in the recent period of geological time, when the country was inhabited by man, and we can trace back the continuance of the same operation of subterranean force to far earlier periods, and upon a greater scale, in various parts of that same coast; nor is there wanting evidence to show that there have been partial subsidences of the land within the historical period. But these changes of relative level of sea and land during the pleistocene period are more distinctly seen on the eastern coast: they were described by Mr. Darwin in his 'Journal,' but in his recent work he has gone into far greater details respecting them,—into a minuteness of description that was not admissible in the plan of his 'Journal,' but which is far more interesting and satisfactory to the geologist.

For a space of more than 1200 miles, from the 33rd degree of S. latitude southward, the land has been gradually elevated, as shown by a succession of terraces one above the other, with abrupt escarpments facing the sea, and separated from each other by gently sloping plains. On the coast of Patagonia, between Santa Cruz and Port

* Page 24.

Desire, there are seven such terraces, separated by plains of various breadths, sloping, though seldom sensibly so to the eye, from the summit of one escarpment to the foot of the next above. The three lower plains are respectively 100, 250, and 350 feet above the sea-level, and the highest of the other four was estimated to be 1200 feet in height. These elevated terraces and plains extend horizontally to vast distances: one ranging from 245 to 255 feet in height appears to extend with much uniformity a distance of 170 miles; another, estimated at a height of from 330 to 355 feet, extends over a space of 500 miles in a north and south line; one in the middle of the great Bay of St. George, estimated at 1200 feet in height, was seen ranging at apparently the same height for 150 miles northward, and some approximate measurements indicate an extension of the first-named terrace to 780 miles. These upraised plains are all strewed with shells of littoral species, still existing as the commonest kinds in the adjoining sea; Mr. Darwin saw them at a height of 410 feet, and he does not know, he says, that that is the maximum height of these remains. "All of them have an ancient appearance; but some, especially the muscles, although lying fully exposed to the weather, retain to a considerable extent their colours. Most of the shells are broken, and the valves are not united; but the fragments are not rounded*."

There thus appears to have been a most remarkable equability in the elevation of these several terraces over a vast area, and the periods of the denudation of the sea-cliffs, which form the escarpments of the terraces, were synchronous along wide extents of coast. It is probable, therefore, that the elevation was by slow and insensible degrees, of which there are some further proofs. Thus on some of the plains there are sand-dunes, at different levels, abounding with shells; and in none of the coast and river sections is there any fault, or abrupt dislocation, or any curvature in the strata. From the quantity of matter that must have been removed by the action of the waves on the shore to form each successive escarpment, it is no less evident that there must have been long periods of rest in the elevatory movement—that it was not constant, but intermittent, as we know to be the case in other countries, and as we find to have been the case, even within the historical period, on the western coast of this continent.

The elevations of the coast of Patagonia began after the adjoining sea was inhabited by the most common and abundant of the existing species of littoral shells, but before the introduction of living mammifers. The remains of extinct mammifers have been found in the lowest plain, in hollows worn in the gravel beds, which are filled by a reddish sandy earth, the same as that which caps the general surface of the gravel. It would be interesting to find out whether similar remains exist in the higher plains; for if they do not, it would mark, approximatively, that the introduction of the mammifers took place long after the creation of the living species of mollusca.

There are proofs no less evident of elevations of the land on the

* Page 13.

western side of the continent during the pleistocene period ; that they were unequal in amount at different parts of the coast; and that the action of the subterranean force was intermittent, periods of rest intervening. Shells of the same species as are now living in the shallow waters of the shores of the Pacific, and in the same proportions as to numbers, are met with in the island of Chiloe at a height of 350 feet above the sea, near Concepcion at 625, and even, according to Lieut. Belcher, at a height which he estimated to be 1000 feet. They occur at the latter height near Valparaiso, and although diminished in number, Mr. Darwin found four species in the same locality at an elevation of 1300 feet. "These upraised marine remains occur at intervals, and in some parts almost continuously, from lat. 45° 35′ to 12° S. along the shores of the Pacific, a distance in a north and south line of 2075 geographical miles; and from the similarity in the form of the country near Lima, it is probable they occur there also, which would extend the line to 2480 miles. From the steepness of the land on this side of the continent, shells have rarely been found at greater distances inland than from two to three leagues; but the marks of sea-action are evident farther from the coast; for instance, in the valley of Guasco, at a distance of between 30 and 40 miles*." That the elevations were gradual, is shown by the shells being all littoral, or such as live at very moderate depths; and by their broken condition, and by their becoming more brittle and having a more ancient appearance the higher they are found, they afford evidence that they had formerly been cast up upon a succession of beaches. The escarpments of the successive terraces, on which shells are strewed, in the sinuosities of the valleys that open to the coast, indicate not only gradual upheavals, but intervals of rest. At Coquimbo there are five such terraces, one above another, in a height of 364 feet.

Although they relate to an earlier period of geological time than that now under consideration, I shall pass to some other parts of the work of Mr. Darwin; and I do so the more willingly, because the phænomena he describes, in the account he gives of his examination of that part of the Cordillera of Chile, are connected with great internal movements, analogous to those which have elevated the land near the coast, on both sides of the South American continent, in comparatively modern periods.

That part of the Cordillera which forms the eastern boundary of Chile is not more than about 60 miles wide ; and, if we except the volcanic peaks, which occur only at distant intervals, the highest mountains do not much exceed 14,000 feet above the sea. The plain of St. Jago, at their base on their western side, is 2300 feet; that of the Pampas, on the eastern side, 3300 feet in height. "Although I crossed the Cordillera," says Mr. Darwin, "only once by the Portillo or Peuquenes Pass, and only once by that of the Cumbre or Uspallata, riding slowly and halting occasionally to ascend the mountains, there are many circumstances favourable to obtaining a more faithful sketch of their structure, than would at first be thought possible

* Pages 53–57.

from so short an examination. The mountains are steep, and absolutely bare of vegetation; the atmosphere is resplendently clear; the stratification distinct, and the rocks brightly and variously coloured: some of the natural sections might be truly compared for distinctness to those coloured in geological works*." The Peuquenes and the Portillo in the one pass, and the Cumbre and Uspallata in the other, are distinct parallel ranges, each differing considerably in composition from the other.

This part of the Cordillera consists of several parallel anticlinal and what Mr. Darwin calls "uniclinal" mountain-lines, ranging north and south: in the main exterior lines, the strata are seldom inclined at a high angle; but in the central lofty ridges they are almost always highly inclined, often vertical, and are broken by many great faults. The strata that flank the chain are traversed by innumerable dykes of igneous rocks, but these are rare in the central parts of the range.

The lowest rock is a porphyritic claystone conglomerate, sometimes between 6000 and 7000 feet thick. The imbedded fragments, which vary in size from mere particles to eight inches in diameter, are both angular and rounded, and both kinds occur in the same mass. Sometimes the rock is a true conglomerate, at other times a breccia. The fragments are claystone porphyry, a felspathic rock like altered clayslate, and occasionally, but rarely, quartz. All the varieties of conglomerate and breccia pass into each other; and by metamorphic action they are changed into porphyries, no longer retaining the least trace of mechanical origin. The fragments Mr. Darwin supposes to have been derived from masses that were ejected from a submarine crater, and those that are rounded he supposes to have been triturated in the heated and agitated water that filled the crater, from something very analogous which he observed in some of the recent volcanos of the Galapagos islands.

Besides the porphyritic conglomerates and the well-characterized metamorphic porphyry, there are other porphyries, which, though differing slightly in composition, have had a distinct origin. They contain large crystals of albite felspar and are often amygdaloidal, with nodules of agate and calcareous spar. They occur in intrusive masses, interstratified with the conglomerate in several alternations, and have all the appearance of submarine lavas, either forced in between the planes of stratification of the conglomerate, or contemporaneous with the deposit of the latter. Volcanic matter of sub-aërial origin is everywhere rare in Chile, the few still active volcanos being confined to the central and loftiest ranges. Metamorphic action has taken place to a great extent; it is seen in the gradual appearance of crystals of felspar and epidote, in the blending of the imbedded fragments of the porphyritic conglomerate, and in the disappearance of the planes of stratification.

Another variety of intrusive igneous rock, occurring in this part of the Cordillera, is that which has been called *Andesite*, consisting either of well-crystallized white albite, or soda-felspar, or of that white mineral analysed by Abich and called by him Andesine, of

* Page 176.

crystals of hornblende, with mica, chlorite, epidote and quartz. Where the mica and quartz are abundant, the rock cannot be distinguished externally from granite. A brick-red granite composed of orthitic or potash-felspar occurs in the Portillo range, which Mr. Darwin is inclined to think is of newer formation than the rock of which albite is the chief constituent.

After ascending the Peuquenes Pass to a height of 7000 feet, a vast formation of gypseous strata begins to appear. It is partly composed of beds of snow-white hard gypsum with a saccharoid fracture, and partly of a pale brown argillaceous gypsum, highly inclined, and conformable in stratification with those of the porphyritic conglomerate on which they repose. The gypseous beds are covered by a red sandstone, seen in some places to be 1000 feet thick; this again is covered by gypseous beds of equal thickness, and these in their turn are surmounted by a repetition of the red sandstone. Above the latter rock there occurs a black, compact, calcareous shaly rock of vast thickness. From these last strata Mr. Darwin collected two Ammonites, a Gryphæa, a Natica, a Cyprina, a Rostellaria, and a Terebratula, which having been examined by M. Alcide d'Orbigny, were considered by him to belong to the Neocomian stage of the Cretaceous system. Fossils collected in another part of the same formation were pronounced by M. von Buch to indicate a formation intermediate between the limestone of the Jura and the chalk, analogous with the uppermost Jurassic beds forming the plains of Switzerland. The fossils collected by Mr. Darwin were imbedded in the rock at the height of 13,200 feet, and the same beds are prolonged upwards to at least from 14,000 to 15,000 feet above the level of the sea. These strata have been greatly disturbed, dipping both west and east, the remnants of an anticlinal ridge, and they also dip towards the centre of the range.

A similar series of beds occurs on the eastern flank of the Cumbre range, but associated with numerous alternations of porphyritic and felspathic rocks, with all the characters of submarine contemporaneous lavas. The flanks of the mountain are here quite bare and steep, affording a section of a series of strata whose united thickness must be nearly 6000 feet: from the lowest to the uppermost bed of gypsum, it cannot be less than 2000 feet. There is however this important difference between the Cumbre series and that of the Peuquenes, that the limestone, containing the same fossils as that of the Peuquenes which lies there near the top of the series, at the Cumbre lies at the very base of the formation, just above the porphyritic conglomerate—that is, several thousand feet lower in the series; and it forms a stratum 80 feet thick. In the opinion of M. von Buch and M. d'Orbigny, the two formations belong to the same age. Professor Edward Forbes has likewise a strong impression that they indicate the cretaceous period, and probably an early epoch in it; and Mr. Darwin himself is of opinion, that probably the gypseous and associated beds in all the sections belong to the same great formation, and he has denominated it *cretaceo-oolite*. Similar strata have been observed farther north in Southern Peru by Mr. Darwin and M.

d'Orbigny, and there is a great fossiliferous formation fifteen degrees northward in Columbia which is considered to belong to the earlier stage of the cretaceous system. "Hence," says Mr. Darwin, "bearing in mind the character of the few fossils from Tierra del Fuego, there is some evidence that a great portion of the stratified deposits of the whole vast range of the South American Cordillera belongs to about the same geological epoch*."

One of the circumstances not the least interesting connected with the occurrence of these cretaceo-oolitic beds at this vast elevation, and in so greatly-disturbed stratification, is the evidence they afford of the elevatory and subsiding movements to which the strata constituting the Cordillera have been subjected. On this subject Mr. Darwin makes the following observations: "It is well-worthy of remark, that the shells contained in the limestone bed of the Cumbre series must have been covered up, on the *least* computation, by 4000 feet of strata. Now we know from Professor Forbes's researches, that the sea at greater depths than 600 feet becomes exceedingly barren of organic beings; hence, after this limestone was deposited, the bottom of the sea where the main line of the Cordillera now stands, must have subsided some thousand feet, to allow of the deposition of the superincumbent submarine strata. Without supposing a movement of this kind, it would moreover be impossible to understand the accumulation of the several lower strata of *coarse* well-rounded conglomerates, which it is scarcely possible to believe were spread out in profoundly deep water, and which, especially those containing pebbles of quartz, could hardly have been rounded in submarine craters, and afterwards ejected from them, as I believe to have been the case with much of the porphyritic conglomerate formation. I may add, that in Professor Forbes's opinion, the species of mollusca that have been described probably did not live at a much greater depth than 20 fathoms, that is, only 120 feet†."

But I have yet to call your attention to other and no less remarkable proofs of repeated upward and downward movements, not only of this great mountain-chain, but of the whole breadth of the continent. All the main valleys on both flanks of the Chilian Cordillera have formerly had, or still have, their bottoms filled up to a considerable thickness by a mass of rudely stratified shingle. In central Chile, the greater part of this mass has been removed by the torrents; cliff-bounded fringes more or less continuous being left at corresponding heights on both sides of the valleys. The thickness of the gravel forming these fringes ranges from 30 to 80 feet, and near the mouths of the valleys it is in several places from 200 to 300 feet. Almost everywhere the pebbles are perfectly rounded, occasionally they are mixed with great blocks of rock, and are generally distinctly stratified, often with parting seams of sand. The plain of Uspallata on the eastern side of the Cordillera, between that great range and the parallel lower range of Uspallata, at a height of 6000 feet above the level of the sea, with a breadth of from ten to fifteen miles, and extending with an unbroken surface 180 miles, is drained

* Page 234. † Page 193.

by two rivers passing through breaches in the mountains to the east. On the banks of one of them, the Mendoza, the plain is seen to be composed of a great accumulation of stratified shingle estimated at 400 feet in thickness. The origin of these accumulations of gravel Mr. Darwin considers to be inexplicable by debacles or ordinary alluvial action. He supposes that the sea formerly occupied the valleys of the Chilian Cordillera, in precisely the same manner as it now does in the more southern parts of the continent, where deep winding creeks penetrate into the very heart of, and quite through this great range; that the mountains were upraised in the same slow manner as the eastern and western coasts have been upraised within the pleistocene period; that on this view every part of the bottom of each valley will have long stood at the head of a sea-creek, into which the then existing torrents would deliver fragments of rocks, which, by the action of the tides, would be rolled, rudely stratified, and the surface of the mass levelled into successive sea-beaches; as the slow rising of the Cordillera would probably be interrupted by long periods of rest. He considers this to have been one of the most important conclusions to which his observations on the geology of South America have led him, "for we thus learn that one of the grandest and most symmetrical mountain-chains in the world, with its several parallel lines, have been together uplifted in mass between 7000 and 9000 feet, in the same gradual manner as have been the eastern and western coasts*."

On the western flank of the Uspallata range, at a height of 7000 feet above the level of the sea, Mr. Darwin discovered, in an argillaceous sandstone, a group of fifty-two stems of trees, part of them silicified, but the greater number changed into carbonate of lime, with cavities lined by quartz crystals. They project between two and five feet above the ground, and stand at exactly right angles to the strata in which they are contained, and which are inclined at an angle of 25°. Specimens which he brought home he submitted to the examination of Mr. Robert Brown, who pronounced the wood to be coniferous, partaking of the character of the Araucarian tribe, with some curious points of affinity with the Yew. The stems have in general nearly the same diameter, about fifteen inches, some twelve, others eighteen inches; they are grouped in a clump within a space of about sixty yards, and all stand at the same level. The strata in which they are contained rest on a thick bed of submarine lava; they are covered by indurated tuffs, passing upwards into a fine-grained purplish sedimentary rock, the united thickness of the argillaceous sandstone and tuffs being from 400 to 500 feet, and upon them is another mass of fine-grained basalt 1000 feet thick; and above this basalt Mr. Darwin could clearly distinguish five conformable alternations, each several hundred feet in thickness, consisting of sedimentary rocks and lavas.

What a wonderful chapter is this spot in the history of the earth! what a tale it tells of repeated elevations and depressions of the land on a vast scale, and all within a comparatively modern period in geological chronology! It is a document written in characters so clear, so intelligible, as to admit of no doubt of their true meaning. They

* Page 67.

are thus read by Mr. Darwin:—"These trees, now elevated to so great a height, have certainly been buried under several thousand feet of matter accumulated under the sea. They obviously must once have grown on dry land; and therefore what an enormous amount of subsidence is thus indicated! As the land, moreover, on which they grew is formed of subaqueous deposits, of nearly if not quite equal thickness with the superincumbent strata, and as these deposits are regularly stratified and fine-grained, not like the matter thrown up on a sea-beach, a previous upward movement, aided no doubt by the great accumulation of lavas and sediment, is also indicated." Did the limits I must observe permit, I could lay before you, from this most instructive volume, many other proofs of the oscillations through a vast vertical range to which the South American continent has been subject, from a period distinctly traceable back in this southern division of it to the oolitic period, and continuing to the present day.

One of the greatest outbursts of plutonic rocks, of syenitic granites and metallic veins, in so modern a period, with which we are acquainted, has been made known to us by Sir R. Murchison in his work on Russia and the Ural Mountains. The gold which is now collected in so great quantities on the eastern flank of the Ural Mountains has been brought to the surface in veins and disseminated through the substance of rocks in this comparatively modern period of geological history. In regard to the subsequent disintegration of these veins and rocks: "the nature of the auriferous shingle, with its subangular fragments, so completely resembles the detritus of lakes, and is so unlike the gravel formed on the shores of seas, that independent of the entire absence of any *marine* remains whatever, whether of tertiary or recent age, all along the immediate eastern flank of the Ural Mountains, there is no room for doubt that the gold detritus was accumulated during a terrestrial and lacustrine condition of the surface*."

The same author has shown by a large body of evidence, that at the time of the spreading of the northern drift over the then submerged country of European Russia, the glacial sea was bounded on the east by the then comparatively low chain of the Urals, which formed the rocky shore of a probably low continent on the east, from which powerful streams descended to the west, from the country we now call Siberia. The subsoil of that region exhibits palæozoic rocks only, covered in part by tertiary accumulations, but without any detritus of the carboniferous or Permian deposits, which cover the more ancient rocks in European Russia. This eastern country, then probably covered with forests, from its inferior elevation and the extension of the northern sea far to the south of its present limits, probably enjoying a climate considerably milder than that which now prevails, appears, from the vast quantities of their bones that are found imbedded in a fossil state over such a vast region, to have been for ages inhabited by large herds of the mammoth,

* Page 492.

rhinoceros, mastodon and aurochs. The country was then also covered to a considerable extent with freshwater lakes, the sites of which are now shown by depressions filled with the detritus in which the bones of these animals were entombed. "Whether discovered in the gravelly detritus or clay on either flank of the Urals, in the high banks of the great streams which respectively flow into Asia and Europe, or in still greater quantities on the sides of the estuaries of the great Siberian rivers upon the glacial ocean, in all cases the mammoths are found entombed in materials which, whether coarse lacustrine shingle near the mountains, or mud and sand at a distance from them, all announce in the most emphatic manner, that these great creatures lived in lands adjacent to lakes and estuaries, in which, during long ages, their bones were interred, and were sometimes carried out to sea and mingled with oceanic remains*."

The present watersheds between Europe and Asia were formed by an increased elevation of the Ural chain, at the time when these animals occupied this eastern land; and their destruction and extinction is ascribed by the author partly to the disturbance of the land by the upheaving forces, but mainly to the change of climate produced by its increased elevation, and its extension towards the north, the low lands of Northern Siberia having been raised above the water, and the shore of the sea consequently thrown much farther back within the arctic region. "In the depressions at the very foot of the chain, the mammoth skeletons are broken up, and their bones, together with those of *Rhinoceros tichorinus* and *Bos Urus*, are rudely commingled in the coarse shingle, derived from the mountains or in the clay above it. In proportion however as we advance into the plains of Siberia, or descend into the valley of the Tobol and the Obe or their affluents, these bones increase in quantity, and are at the same time in much better preservation.—The wide and low tracts of Northern Siberia, in which these remains are most abundant, were then beneath the sea, and the bones must have been drifted thither, and possibly for some distance.—All the low promontories between the Obe, the Yenesei and the Lena, which lie northwards of the ancient ridges and plateaux, were under the waters and estuaries at the periods when the mammoths ranged over the Ural, the Altai, and the adjacent region of Siberia then above the sea†."

The form of the ground where the detritus is accumulated, shows that it was deposited after the present configuration of the land had been to a great extent established, when the present valleys existed; for it fills up all the original inequalities of the inferior rocks, which in many places exhibit appearances of having been worn into holes and cavities, as if by the powerful action of water. The ground is composed entirely of the stony materials of the adjoining hills; there are no boulders of far-travelled rocks. It is usually from two to twelve feet thick, but there are accumulations of this detritus of more than fifty feet thickness. It is often covered by a thick mass of clay, and this last by peat and bog earth; so that as the

* Page 500. † Page 494–499.

Megaceros in Ireland and the Isle of Man is entombed in lacustrine deposits covered with peat, so are the extinct mammalia of Siberia in similar formations of a like age.

We learn from the recent observations of Mr. Lyell, that in the same modern geological epoch during which Siberia was inhabited by herds of the mammoth, rhinoceros and aurochs, the continent of North America was the abode of mammalia now extinct, their remains being found in deposits of gravel associated with existing species of fluviatile and terrestrial testacea, and also with marine shells of the same species as are now living in the neighbouring sea. Thus at Geneseo, in lat. 42° 50′, he saw the skull, ivory tusks and vertebræ of a mastodon, dug out of a bed of shell, marl and sand, the shells being all of existing freshwater and land species now common in that district*. He visited two other localities in Albany and Green counties in the state of New York, where the same remains had been found in similar circumstances. On the sea-shore near Savannah, he disinterred from a bed of clay the grinder of a mastodon, the clay resting immediately on sand containing marine shells of living species; and a tooth of the mylodon was found in the same spot. Farther south in Georgia, in lat. 31° 25′, two entire skeletons of the megatherium were met with. "It is evident," says Mr. Lyell, "from the observations of Mr. Hamilton Cooper and my own, that at a comparatively recent period, since the Atlantic was inhabited by the existing species of marine testacea, there was an upheaval and laying dry of the bed of the ocean in this region. The new land supported forests in which the megatherium, mylodon, mastodon, elephant, and a species of horse different from the common one, and other quadrupeds lived, and were occasionally buried in the swamps †." On the western side of the Alleghanies, in Kentucky, at the spot called the Big Bone Lick, in lat. 38° 50′, entire skeletons of extinct animals and the separate bones have been found in black mud, containing recent terrestrial and freshwater shells about twelve feet below the surface. "It is supposed that the bones of mastodons found here could not have belonged to less than a hundred distinct individuals; those of the fossil elephant (*E. primigenius*) to twenty; besides which, bones of a stag, horse, megalonyx and bison are stated to have been obtained. It is impossible to view this plain," Mr. Lyell adds, "without at once concluding that it has remained unchanged in all its principal features from the period when the extinct quadrupeds inhabited the banks of the Ohio and its tributaries ‡."

Dr. Daubeny read last year before the Ashmolean Society of Oxford a paper which contains an account of the extinct volcano of Rocca Monfina near Naples. It is very remarkable that a volcanic mountain of such magnitude as to be nearly 3300 feet in height, having a circular crater more than two miles and a half in diameter, with a conical hill rising from the centre high above the outer edge of the crater,

* Travels in North America, vol. i. p. 55.
† Id. p. 164.
‡ Id. vol. ii. p. 65.

should hitherto have been so little an object of attention, in a country so frequented, on the very borders of the Phlegræan Fields, visited and described by so many geologists. Breislak, in his 'Voyages Physiques et Lithologiques dans la Campanie,' published in 1801, refers to it cursorily, but does not appear to have examined it with any care; Dr. Daubeny himself, in his general work on volcanos, published in 1826, gives only a general outline of its structure in half a page; Mr. Lyell in his account of the volcanic district of Naples makes no mention of it*; neither does Friedrich Hoffman in 1832†, nor M. Dufrenoy in his 'Mémoire sur les Terrains Volcaniques des environs de Naples,' published in 1838. M. Abich appears to have been the first geologist who had examined Rocca Monfina with care; he spent three weeks in the investigation of it in 1838, and has given an account of it in his work published in the autumn of 1841, 'Ueber die Natur und den Zusammenhang der vulkanischen Bildungen,' which, though brief, is accompanied by two excellent maps. He tells us that M. Pilla of Naples, having seen his map, subsequently examined the mountain; and there is in the eighteenth volume of the 'Annales des Mines,' which appeared in the spring of 1841, an account of Rocca Monfina by M. Pilla; without however any mention of the labours of M. Abich, who had preceded him.

This mountain lies about 30 miles N.W. of Naples, immediately above the towns of Teano and Sessa, the river Garigliano washing its base. The summit of the conical hill that rises from the centre of the crater, called the *Monte de Santa-Croce*, was the stronghold of the Aurunci, who successfully resisted the power of Rome until A.U.C. 410. As vestiges of the ruined city are still to be seen, and as the Aurunci are mentioned at a very early period in Roman history, it is clear that there has been no eruption for at least 2500 years. The interior of the crater is covered with a fertile soil and clothed with vegetation, as is the central cone; and Dr. Daubeny tells us that the late Sir W. Gell observed to him, that "a nation like the Aurunci, to whom it was of essential importance to have near their city good pasturage for the flocks and herds, on which they depended for support, would never have selected Rocca Monfina for their capital, not only if the volcano itself had been in activity, but had not the stone which constitutes the interior of the crater been already in such a state of decomposition as to be covered with herbage, and to yield abundant crops." We have no means of estimating the period when the volcano was in activity, but this we know, that the mountain must have been formed by a sub-aërial eruption, that it has never since been submerged, and therefore that its age is posterior to that very modern period in geological chronology when the species of mollusca now found in the neighbouring sea were in existence, and when the country was inhabited by the elephants whose remains are met with in the superficial soil.

This volcanic group is continuous with, or rather included in, an offset of the Apennines, the celebrated *Mons Massicus*, composed of

* Principles of Geology, ii. ch. 11, 12.

† Geognostische Beobachtungen, published in 1839.

Apennine limestone. The external truncated cone is composed, according to Dr. Daubeny, who visited the locality, of an earthy volcanic tuff mixed with mica and occasionally pumice; a red ferruginous variety is sometimes seen in beds, alternating with the more common kind, and in one instance forming a kind of vein running vertically through the strata.

The external cone rises with a gentle slope from the base, attaining near the summit an inclination of 18°. The brim is more than 2000 feet high, and is complete throughout half the circumference, this portion of the original crater remaining perfectly intact. This part of the mountain is called Monte Cortinella, and by the map it appears to be continuous for more than three-fourths of the circumference, and Dr. Daubeny says that it may be traced in other parts throughout its entire circumference, except in one place. The outer brim is covered over with loose or compacted aggregates of volcanic sand, and of stones promiscuously heaped one upon the other. Blocks of a kind of porphyry, composed of a decomposing felspar, including large crystals of leucite and minute crystals of augite, are often imbedded in the tuff, and a little below the external margin there is a bed of this leucitic porphyry continuous for some distance. The external cone has a steep inner escarpment, forming the crater, enclosing a great plain, from the centre of which rises the conical mount of Santa-Croce, about three-quarters of a mile in diameter at its base, and rising to a height of 1082 feet above the inner plain, towering considerably above the brim of the crater at its highest point, in the Monte Cortinella. The plain is thus about three-quarters of a mile broad between the base of Santa-Croce and the escarpment. These measurements are not all contained in the memoir of Dr. Daubeny, they are partly taken from that of M. Pilla. The summit of the conical hill is exactly equidistant from all parts of the crest of Monte Cortinella. It is composed of a fine-grained compact rock, a trachyte containing much mica, and Dr. Daubeny assumes that the whole hill is composed of this rock; but as he tells us that, abrupt as it is, it is everywhere covered with vegetation, it is possible that it may not be of so simple a composition; a doubt I may be permitted to express, as he lays so much stress on the structure of this interior mount, in his theory of the formation of the group.

M. Abich, M. Pilla, and Dr. Daubeny agree in considering Rocca Monfina as a very perfect example of a crater of elevation. Dr. Daubeny thus expresses himself:—"The circumstance which, in a geological sense, attaches the highest interest to the structure of this mountain, is the support which it appears to afford to the *theory of elevation*."—"A conical mass of rock so considerable, and yet so completely circumscribed within the area of the crater, could only, as it would seem, have been brought into the position which it is seen to occupy, by being upheaved *all at once* from the interior of the globe, whilst in a semi-fluid or pasty state, but not in a condition of actual liquidity."—"Alternating strata of tuff and lava may indeed be imagined to build up in the course of time a mountain of considerable elevation, but a hill consisting of tuff alone, as appears to be the case with a large part at least of Rocca Monfina, could only have attained its present height in consequence of some elevatory movement subsequent to its ejection; and if this be admitted, we have before us, in the central trachytic rock of Monte della Croce, an agent calculated to cause such an upheavement, and itself hardly to be accounted for without such a supposition."

To this theory of the formation of Rocca Monfina, it appears to me that the following objections may fairly be urged. In the first place, the advocates of the theory of elevation have never yet been able to give a satisfactory answer to the general objection, so frequently urged, that if, by the application of a force from beneath, a series of horizontal sedimentary deposits were suddenly elevated, so as to form a conical mountain with a central cavity or crater, the brim of that crater could not be continuous; it must necessarily be rent by numerous fissures, that would be widest at the brim, become gradually narrower towards the base, and finally disappear. Now Dr. Daubeny and M. Pilla both describe the brim of the original crater, for a large part of the circumference, as unbroken—as "*absolutely intact.*" In the second place, if the trachytic cone raised up the horizontal beds of tuff, although it is very possible that it might be in a pasty state and might protrude, still the beds of tuff it raised up would lie upon its sides all round. Now we are told, that not only is there no tuff on the Monte de Santa-Croce, but that it stands isolated in the centre of an area, with its base more than three-quarters of a mile from the inner escarpment of the crater. The height of the escarpment above the interior plain from which the Monte de Santa-Croce rises is not given; but whatever it is, the removal of the whole mass of materials from the space between the conical hill and that escarpment, has to be accounted for by the elevation theory; and it is not easy to conceive by what agency this could have been effected.

It would not be at all contrary to what has been seen in other volcanic mountains, if we suppose that the external cone was formed, in great part, by materials erupted from a central vent; that after a repose of some duration, there should be a subsidence in the interior, leaving Rocca Monfina in the same state as Vesuvius is represented to have been in the time of Strabo, as shown in the figure that accompanies Dr. Daubeny's memoir; that subsequent volcanic action, that had been long dormant, should again burst through the old vent, the weak part of the incumbent mass; and that lava in a pasty state should be protruded, which would settle into a conical form, if the whole of Monte de Santa-Croce be so composed.

Dr. Daubeny, in arguing in favour of the elevation theory, adverts to the marine fossil shells found on the sides of Somma, as a proof that that mountain was formed by the upheaval of sedimentary deposits. If such remains had been found in a continuous bed, the evidence would not have been conclusive, for Somma may have been a cone formed by submarine eruptions, since raised in mass; but it is admitted that the shells are found in loose blocks in the tuff, and also in the tuff itself. As the sand and comminuted matter ejected from existing volcanos are frequently found to contain infusorial remains, it is clear that the volcanic force has acted upon aqueous deposits lying above it in the interior of the mountain, which it has reduced to powder. It is not therefore an improbable supposition that the blocks on the sides of Somma are fragments of sedimentary strata broken up by the volcanic action and thrown up through the vent.

In conformity with the plan I have followed in this Address, were there not a sufficient reason in the length to which it has already extended, I ought not to enter upon the consideration of any of the works published in the last year that treat of the older formations; but I cannot deny myself the satisfaction of calling your attention to the memoir of Sir Henry de la Beche, which I have already alluded to, on the formation of the rocks of South Wales and South-western England, for I consider it the most comprehensive and most important work relating to this period in the Geology of England which has appeared since the publication of the 'Silurian System' of Sir Roderick Murchison. It is the first of the series of essays in the first volume of the 'Memoirs of the Geological Survey of Great Britain,' and occupies 300 closely printed large octavo pages, so that the mass of information it conveys is immense. Four-fifths of it refer to the palæozoic rocks, and the igneous rocks associated with them; in the remainder of the essay there are many valuable details respecting the New Red Sandstone, for which the author retains the name given by the Rev. Wm. Conybeare of the *Poicilitic* series, and also respecting the lower parts of the Oolitic series, that occur westward of a line drawn from Lyme Regis to the borders of Shropshire. Even a brief analysis of the most important parts of this essay would extend far beyond the space to which I must limit myself. As a topographical guide and companion to the geological map of the Survey, the memoir is invaluable; and it abounds in proofs how eminently fitted the author is to teach others "how to observe in geology." I know no portion of any country the geology of which has now been more thoroughly examined and described than the west of England; and I cannot conceive a more instructive or more agreeable occupation for a geologist, whether he be already well-versed in the science, or be a student acquainted only with the elements of it, than to travel through these western counties and South Wales, with the geological maps and sections of the Survey, this volume of memoirs, Sir Henry de la Beche's former report, the joint memoir of Sir R. Murchison and Professor Sedgwick on the Physical Structure of Devonshire, and the 'Figures and Descriptions of the Palæozoic Fossils of Cornwall, Devon, and West Somerset,' by Mr. Phillips. When he arrives at the places of which they treat, he will also find most valuable assistance from the papers of Austen, Lonsdale, Buckland and Conybeare, that treat of this country.

Although I am unable to lay before you even an outline of that which may be learned from the study of the memoir of Sir H. De la Beche, I will call your attention to some parts of it which appear to me of special interest.

The first I shall advert to are the proofs he brings forward of extensive volcanic action throughout the whole series of the palæozoic rocks. There is evidence, he tells us, "that during the period when the Llandeilo flags and their equivalents in the Silurian system were accumulated over the area extending from Malvern to Pembrokeshire, volcanic points existed from whence molten matter and often ashes were ejected, and were intermingled with the detrital accumulations of the period;" that "trappean ash, the volcanic ash of the period, was mingled with the gravels and sands now forming conglomerates and sandstones, that it was accumulated in beds, interstratified with mud and sand, and that the remains of the crustaceans of the day are found in it." This ash, moreover, he is of opinion points to *sub-aërial* volcanos, and probably therefore to land from which it may have been carried within a moderate distance*. This ash often covers an area of great extent. The facts of the contemporaneous existence and interstratification of igneous rock with the fossiliferous and inferior slates had been before pointed out by Professor Sedgwick and Sir R. Murchison, and the latter in his 'Silurian System' frequently adverts to the intermingling of volcanic ashes; but, if I am not mistaken, Sir H. De la Beche is the first who has pointed out the probable existence of *sub-aërial* volcanos at that remote period of the earth's history; that is, active volcanos on land, prior to the eruption, as I shall presently mention, of the granite of that region, which at no distant period geologists were accustomed to consider as the deep-laid foundation on which all the superincumbent slates rested; on which slates also the venerable name of primitive was conferred.

Ascending in the series, he describes Devonian strata near Tavistock, argillaceous slate and limestone intermingled with fused trap and ashes, a pumice filled with carbonate of lime, and the remains of mollusks in ashes; and much ash and vesicular igneous rocks are intermingled, he says, with the beds of the South Devon limestones†.

Treating of the carboniferous series, he describes Brent Tor as presenting a mixture of trap rocks, ash, and a conglomerate containing vesicular portions of igneous rocks, which approach the condition of pumice; and adds that "these rocks are associated in a manner such as is often seen in volcanic countries ‡."

The author is of opinion that the protrusion of the granite of Cornwall and Devon clearly took place after the deposit of the coal-measures of Devon, and anterior to that of the Newred sandstone series. "The Devon and Cornish granites," he says, "seem to have been thrust up through points of least resistance, in a line extending from the southern part of Devonshire to the Scilly Islands, part having protruded through the weakest places, and the remainder still concealed beneath, supposing this granite connected below, at moderate depths, during the whole distance§."—"From the Scilly Islands to Dartmoor inclusive, we seem to have the upthrust of one mass, which found points of less resistance amid the superincumbent accumulations more in some places than in others. As the masses rose, the edges of the detrital, trappean and

* Pages 30 to 35. † Pages 84 to 90. ‡ Page 137. § Page 228.

calcareous beds against which they pressed were frequently fractured, and into the fractures the granitic matter was forced, forming the granite veins, as they have been termed, which can often be traced terminating in somewhat fine threads; so that not only was the pressure great, but the fluidity of the igneous rock sufficient to pass into small rents and cracks." He makes the following important remarks:—"When we observe the mode in which the granites of Cornwall and Devon have been brought into their present position, it is evident that they have not been intruded in the manner so common among the trappean rocks in this region. We have nothing resembling the accumulations of ashes or cinders, nor the lines and masses affording sections like those of upturned lava streams or sheets of matter ejected from craters, and widely covering subjacent detrital or calcareous accumulations*."

The following cases of metamorphic action and the observations of the author upon them are highly interesting:—"Some of the changes of the sedimentary deposits, effected by the heated molten rock in juxtaposition, have even amounted to a melting of such rocks and their consequent incorporation, in part, with those in igneous fusion at the time. There can be little doubt that detrital rocks, chiefly composed of felspathic matter, have been so melted between two masses of greenstone, greenstone porphyry, and vesicular trap, as to form one body with them, their original bedded character appearing both on the north and south, and the change from the one condition to the other being very gradual. Great care is required, while studying this portion of country, not to confound trappean substances with true fused rocks, since organic remains are to be discovered in many beds which, at first sight, perfectly resemble those which have undergone fusion. Some colourless argillaceous accumulations have become by metamorphic action large natural beds of biscuit china, the elementary substances being the same as a potter might employ for the purpose. Rocks of this class, though not of the finer varieties, are seen to contain crystals of felspar, so as to constitute a sort of porphyritic slate; a kind of alteration showing, that the conditions attending it were such as to permit a movement of particles; so that some of the component elementary substances could adjust themselves in a definite manner, and complete the crystallization of the compound formed, while the remainder retained a coarse porcellanic character, the body of the rock keeping the lamination due to the original deposit of fine detrital matter from mechanical suspension in water†.

There are many other observations throughout the work on chemical action, exemplified in many of the phænomena described, which are very important, as leading to a more correct understanding of the true nature of the rocks. I will give as examples those that relate to the colouring matter of the greenish-blue bands and spots of the red-sandstones, and to the formation of clay-ironstones. A large extent of country, in Herefordshire, Shropshire and South Wales, is covered by the old red sandstone deposit. It is estimated that there is an unbroken surface of 2100 square miles, and taking the average thick-

* Page 232. † Page 33.

ness of the mass, as it appears from measuring the beds vertically to their outcrop, there are more than 1500 cubic miles of, chiefly, red-coloured detrital matter. These beds afford, comparatively, few animal remains, and those chiefly in the lower portion, while below them are a series of strata often teeming with organic remains. No sooner did these red-stained beds cease to be deposited than marine creatures again resorted to the waters above them, as we see by the carboniferous limestone that rests upon the old red sandstone. A great change of physical conditions therefore must have taken place from the commencement of these red beds. Peroxide of iron mechanically suspended in rivers is known to be fatal to the animals previously living in them. We can thus account for their great rarity both in the old red and new red sandstone series; but as yet nothing has been discovered to lead us even to conjecture whence this enormous quantity of iron in deposits formed out of the detritus of pre-existing rocks has been derived. Analyses show that marls of the old red sandstone have yielded 6 per cent. of peroxide of iron, and those of the new red nearly 10 of peroxide and 4½ of protoxide. But there is a well-known character common to both, that which is the origin of the term poicilitic as applied to the new red sandstone, viz. the prevalence of layers, stripes and patches of a bluish-green and grey colour; the cause of which has hitherto been a matter of great difficulty to account for. Sir H. de la Beche states that Captain James, R.E., has pointed out the probability that the clefts and joints of the rocks are changed from red to bluish-green by the percolation of water charged with vegetable matter, which, under certain conditions, changes the peroxide into a protoxide*. "With the knowledge," he says, "that under the conditions where vegetable acids are forming in contact with peroxide of iron, the latter is robbed of part of its oxygen, and converted into a protoxide, it is interesting to consider if the colours of these greenish bands (often very marked, and continuing over the same planes amid the red rocks for considerable areas, showing the operation of some common and widely-spread contemporaneous cause over them,) may not be due to a change produced upon the peroxide of iron by vegetable matter. Throughout the Silurian rocks, and above the black slates (formerly black mud), wherein carbon is found, we cannot suppose the animals whose remains are often so abundantly entombed in the mud, silt and sand of the time, to have existed without marine vegetation, though we commonly find no trace of it, the vegetation with the soft parts of the animals having been decomposed, partly into acids, and partly into different gases, which if coming into contact with peroxide of iron would convert it into protoxide," the state in which it exists in the bluish-green parts of the sandstones. Some analyses of the blue marl, conducted in the laboratory of the Museum of Economic Geology, led Dr. Lyon Playfair to remark that the carbonic acid is greater in the blue than in the red marl, because the carbonic

* Since this Address was delivered, I have been reminded that Mr. J. Dawson of Pictou, in a paper read before this Society 22nd January, 1845, suggested that the bleaching of the red-sandstone may have been caused by the decomposition of vegetable matter.—Quart. Jour. of Geol. Soc. i. 327.

acid from the decaying vegetable matter has united with protoxide of iron to form the carbonate*.

On the theory of the formation of the ironstone bands and nodules of the coal-measures, which, as you know, often contain impressions of plants and also freshwater shells, our author makes the following observations:—"The clay or argillaceous ironstones are formed of carbonate of iron, mingled mechanically with earthy matter, commonly corresponding with that constituting the shales with which they are associated. In many of the underclays of the coal the ore occurs in nodules irregularly distributed. Mr. Hunt, of the Museum of Economic Geology, instituted a series of experiments to illustrate the production of these clay ironstones, and he found that decomposing vegetable matter prevented the further oxidation of the protosalts of iron, and converted the peroxide into protoxide of iron, by taking a portion of its oxygen to form carbonic acid. Under the conditions necessary for the production of the coal distributed among the associated sand, silt and mud, the decomposition of the vegetable matter would necessarily form carbonic acid among other products. This carbonic acid mixed with water would spread with it over areas of different dimensions according to circumstances; forming salts and meeting with the protoxide of iron in solution, it would unite with the protoxide and form a carbonate of iron. The carbonate of iron in solution would mingle with any fine detritus which might be held in mechanical suspension in the same water, and hence when the conditions for its deposit arose, which would happen when the needful excess of carbonic acid was removed, the carbonate of iron would be thrown down mingled with the mud †." If not in sufficient quantity to form continuous beds, it would aggregate into nodules, and be arranged in planes amid the mud, in the same manner as is so commonly seen to be the case with argillaceous limestones and nodules of various geological ages.

PALÆONTOLOGY.

During the course of the past year several important contributions have been made to this department of our science, both at home and abroad. Through the liberality of Mr. Richard Griffith, a valuable account has been published of the Silurian fossils of Ireland, drawn up by Mr. McCoy, and illustrated by excellent figures. Numerous new species, many of them of great interest, are described, and the localities from whence the specimens had been collected are fully stated. This work throws new light on the relations of the English and Irish Silurian strata.

In the Journal of our Society for the year 1846 are many contributions to British palæontology, but to these it is unnecessary for me to refer. In the course of the year, the first number of a new periodical work appeared, 'The London Geological Journal and Record of Discoveries in British and Foreign Palæontology,' which contains some interesting communications respecting new British fossils from Eocene, Cretaceous and Permian strata. We find in it a memoir by Mr. Serles Wood, in which he has announced the discovery of an

* Pages 51, 52, 53, 255, 264. † Page 185.

alligator and of several new mammalia in the eocene beds of Hordwell Cliff in Hampshire; of a new Bulimus from the same formation near London; of a species of Mososaurus from the chalk of Essex by Mr. Charlesworth; of a new species of Ichthyosaurus from the lower chalk in the vicinity of Cambridge; and Mr. King of Newcastle on Tyne has made known to us the existence of a Chiton in the magnesian limestone of Sunderland, a genus of very rare occurrence in the fossil state, and of which a Silurian species has been described by Mr. Salter in a paper read before us last June, and published in the number of our Journal which appeared on the 1st of this month.

On the Continent, new works on palæontology appear in rapid succession. Among the most recent, the 'Palæontographia' of Durker and Von Meyer, and the 'Petrefactenkunde Deutschlands' of Professor Quenstedt may especially be mentioned, on account of the beauty of their illustrations. The latter work contains excellent figures and careful and fully-detailed descriptions of fossil Cephalopoda. The researches of Beyrich on Trilobites and of Volborth on Cystidea may also be noticed on account of their interest to the student of British palæozoic fossils. Numerous new Trilobites have been described in a little work on the Silurian strata of Bohemia by M. Barrande, well-worthy of the attention of the geologists of this country; but it is very desirable that figures of the new forms therein announced, and too briefly described, should be speedily published.

One of the most valuable contributions to palæontology from the Continent, during 1846, is the admirable account of the fossils of Petschora by Count von Keyserling, illustrated by excellent drawings, forming a worthy supplement to M. de Verneuil's researches in Russian palæontology.

It now only remains for me, before quitting this Chair, to express to you my deep sense of the obligation I am under to you, for the pleasure I have had during the last two years in the discharge of the duties of your President. I became a member of this Society a few months after its foundation, now nearly forty years ago, and the active part I have lately had to take in the management of your affairs has renewed the pleasures I enjoyed as one of the secretaries, in my younger days, for nearly six years. To the Geological Society I am directly and indirectly indebted for some of the chief sources of my happiness throughout the greater part of my life; and gratitude alone will prompt me to lose no opportunity of advancing its honour and usefulness, were I ever to cease to take an interest in the progress of our science; an abandonment of an old attachment which I shall not contemplate as possible. It gives me much satisfaction, that, by the choice you have just made, I am to be succeeded by my distinguished friend Sir Henry De la Beche; one so able, and so determined, I am convinced, to show during his presidency, that this Society continues to be a powerful instrument for the advancement of geological science, a centre of good fellowship, and a band of independent scientific men, who will steadily and fearlessly promote the cause of truth.