ADDRESS

DELIVERED AT

THE ANNIVERSARY MEETING

OF THE

GEOLOGICAL SOCIETY OF LONDON,

On the 17th of FEBRUARY, 1843;

PREFACED BY

THE ANNOUNCEMENT OF THE AWARD

OF TWO

WOLLASTON MEDALS AND THE DONATION FUND

FOR THE SAME YEAR.

BY RODERICK IMPEY MURCHISON, F.R.S.,

PRESIDENT OF THE SOCIETY.

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AWARD

OF

TWO WOLLASTON MEDALS AND THE DONATION FUND

FOR 1843.

[From the Proceedings of the Geological Society, Feb. 1843.]

OBSERVATIONS BY THE PRESIDENT.

THE Report of the Council having acquainted you that Wollaston Medals have this year been adjudicated to MM. Dufrénoy and Elie de Beaumont, I beg to preface their delivery by a very few observations.

With liberal and enlightened views, Dr. Wollaston left the Council of this Society perfectly unfettered in the selection of persons qualified to receive the proceeds of a fund, which he bequeathed to us for the purpose of encouraging geological researches, or of rewarding those who may successfully complete them. In founding a medal which bears on it the likeness of that great philosopher, we recognised the principle of reward for eminence in geological labours, whilst the surplus interest of the fund was to be annually bestowed on some man of science employed in the accumulation of facts. In the course of the Address which I am about to read, the useful application of one of these donations will be pointed out, and in the mean time I will briefly advert to the destination of the two Gold Medals, which have been voted to M. Dufrénoy and M. Elie de Beaumont, for their Geological Map of the kingdom of France.

Of the peculiar excellences of this splendid work, as creditable to the French Government who fostered it as to the geologists who executed it, I expressed unqualified approbation in my Discourse of last year, soon after the map was sent to us; and I dwelt with great satisfaction on the assurance of its authors, that they had pleasure in offering it to us, as, in our own islands, when young geologists, they first acquired that knowledge of the classification of sedimentary deposits which led them to embark in their great national enterprise.

To treat of all the merits of our distinguished Foreign Associates, would be to enter, not only upon the geology of France, but also on the structure of other tracts of the surface of the globe on which their labours have shed so much light. I will therefore simply express my sincere belief, that the Council of this Society never

made an award more creditable to its just appreciation of high geological merit.

In heartily congratulating you, Gentlemen, in having done honour to yourselves by adding the names of Dufrénoy and de Beaumont to the list of those foreign philosophers who have won the meed of your applause, you have, I am convinced, raised the value of our medals in the estimation of all cultivators of geology; and in handing them to our Foreign Secretary, for transmission to our French Associates, I beg he will express to them, that in this award we view them, not as foreigners, but as friends and leaders, from whose writings we have received both instruction and delight, and whose successful career we have thus endeavoured to honour by the choicest gift we have it in our power to bestow.

In presenting the Medals to Sir H. De la Beche, Mr. Murchison rose and said,—

Sir Henry, I have to request you to make known to our eminent French Associates, how highly we prize their services; a task which may indeed be well confided to you, as, by your long-continued and active labours in the same departments of our science, you are better qualified than any member of this Society to appreciate the high order of merit of the Geological Map of France.

Sir Henry De la Beche, in reply, expressed the sincere gratification it afforded him to receive the Medals on behalf of his friends MM. Dufrénoy and Elie de Beaumont. It would be superfluous, he said, in any assembly of geologists to advert to the labours of such men; they were known and fully appreciated by the world, and the Geological Map of France spoke for itself. MM. Dufrénoy and Elie de Beaumont had desired him to express to the Society the high estimate they entertained of the honour conferred upon them; and he felt assured that the Society could not but experience great gratification in thus endeavouring to show its deep sense of the important benefits which, in common with the geologists of all nations, it had derived from the works of these distinguished men.

The President then handed the balance of the Wollaston Fund to the Secretary, Mr. W. J. Hamilton, to promote the publication of Mr. Morris's tabular work, the merits of which were adverted to last year, and then commenced his Address.

ADDRESS

TO THE

GEOLOGICAL SOCIETY,

Delivered at the Anniversary, on the 17th of February, 1843.

By RODERICK IMPEY MURCHISON, F.R.S.,

PRESIDENT OF THE SOCIETY.

GENTLEMEN,

THE past year has been favourable to the duration of the life of geologists, for we have lost no one working member. Some, however, of our Associates have passed from this stage of existence, and I will briefly allude to three, whose position and literary talents, or connection with our pursuits, seem to me to claim notice.

In the first place, I have to pay a tribute to the late President of the Royal Asiatic Society, the EARL OF MUNSTER, the companion of my boyhood and the friend of maturer years. Educated at the Royal Military College, and with no other advantages than those which fall to the lot of other young soldiers, George Fitzclarence early shared in the bitter hardships and final triumph of the Corunna campaign; and, taking an active part in the Peninsular war which followed, he was repeatedly wounded and once taken prisoner, owing to the gallant exposure of his person. The esteem of his great commander, thus won in the field, attended Lord Munster to the close of his life. Without tracing the career of my friend in India, where he served on the staff of the Governor-General, or following him through his travels in Egypt, where he explored the pyramids with Salt and Belzoni, I may say that with his acute and observant mind, he there imbibed a taste for Eastern art and story; and, taking a comprehensive view of those countries and their people, he laid the foundation of that acquaintance with Oriental subjects which formed the chief object of his subsequent researches. The military annals of the nations of the East naturally attracted so

enthusiastic a soldier, and fifteen years have now elapsed since he first conceived the plan of a history of Oriental Castrametation or the science of encampments from the earliest ages. With the progress of his inquiries, however, and with fresh materials, his views enlarged; and another work on a gigantic scale was commenced, which was designed to embrace the tactics and warfare of all Oriental nations, interspersed with ethnical notices from the earliest records down to the wars of British India. Some idea may be formed of the vastness of this undertaking, unhappily arrested by the death of its projector, from the fact, that the materials he had already collected with unwearied industry, and sometimes at great expense, in the libraries and archives of Europe and Asia, fill 2000 quires of folio paper; exclusive of a vast store of rare plates and detached memoranda bearing on his subject. Let us hope that the accomplished young scholar, Dr. Sprenger, whom his Lordship selected to translate many of these documents from the Arabic and other Eastern languages, or some fitting member of the Asiatic Society, may be found to prepare for publication the most important of the results at which he had arrived. So widely were his correspondents distributed, that they extended to Orenburg and Astrachan, the remotest limits of the Russian empire; and in the University of Kasan, where, I would observe, more knowledge of the East is to be obtained, both in historical and in numismatic lore, than perhaps in any other city of Europe, it was truly gratifying to me to find the name of my friend occupying a high place in the estimation of learned Oriental Professors.

As a member of this Society, Lord Munster took a warm interest in our progress. So persuaded was he of the practical value of geology, and so desirous of communicating a knowledge of it to his children, who were his constant companions, that he ingeniously devised a model of the crust of the globe, which served to convey a good elementary notion of the succession of the principal strata, and the derangements to which they have been subjected by the eruption of intrusive rocks. This anecdote will, I trust, not be considered irrelevant in addressing associates who can discern the merits of the man in his domestic relations; and in these Lord Munster was most exemplary. I cannot better terminate this brief sketch of one whom I loved, than by referring you to the eloquent

panegyrics which have been paid to his memory, both by the Royal Asiatic Society, over which he presided, and by a gallant brother-soldier and respected Fellow of this Society, who, like myself, had been through life the attached friend of the Earl of Munster*.

The blank which has been left in the world of letters by the death of Dr. Arnold has been deeply felt, and the loss of a man of such profound erudition and high moral excellence is justly bemoaned by an eminent contemporary as a national calamity†. It is not for the President of this Society to attempt even a sketch of the broad lights in the character of this fervid lover of truth, nor to follow him in his useful career during the thirteen years in which he was the chief master of the great school at Rugby; but, admiring the vigour and independence of his mind, and reverencing his strenuous efforts to enlarge the bounds of education, I cannot omit to place on record, that the enrolment in our ranks of Dr. Arnold is a testimony borne by a good man, and an eminent scholar, to the usefulness and importance of geological inquiry, in the advancement of which, at the University of Oxford, under his friend Dr. Buckland, he cordially rejoiced. Though not a practical geologist, he held the pursuit in high honour, and more especially estimated its value as the true basis of physical geography.

Mr. Thomas Botfield of Hopton Court, a much-respected and very old member of this Society, came among us when geology was held at a low public estimate, and when its importance was ill understood, even by cultivators of other branches of physical science. Endowed with a very sagacious mind, he not only took an interest in our speculations and theories, but was strongly impressed with the practical beneficial results to be obtained from a cultivation of the positive departments of our science; and of this he gave the strongest proof, by selecting the Titterstone Clee Hill in Shropshire as the seat of his mining operations. Aware that this little elevated and detached coal-field was surrounded by older rocks, and that no similar mass was to be found between it and the heart of the adjacent country of Wales, he saw that by piercing the basalt by which

* See Trans. Royal Asiatic Society, Anniversary 1842; and a short eulogium in the United Service Journal, 1842, vol. i. p. 565, written by Major Shadwell Clerke.

† Edinburgh Review, No. 151.

it was covered, and by opening out the mountain in a scientific manner, he would render himself, to a great extent, the supplier of fuel to a large region. By this successful enterprise he amassed a considerable fortune, which he employed in hospitality and benevolence during a long and well-spent life.

OFFICIAL CHANGES.

The official change occasioned by the retirement of Mr. Lonsdale having been adverted to in the Report of the Council, and the warmest thanks of this Meeting having been voted to him, I would now express my own sense of the meritorious services of that officer.

Fourteen years, Gentlemen, have elapsed since his appointment was made; during which time your collections and your volumes attest the arduous and successful labours of your Curator and Librarian. Reorganizing our Museum, and naming a multitude of species after most elaborate comparisons with foreign and British types, he, at the same time, undertook and performed nearly the whole of the scientific duties which were formerly discharged in great measure by our honorary secretaries; and this too at a period when currents of fresh knowledge were rapidly setting in, and when our literary machinery had been rendered much more complex than in the early days of our body, through the addition of long and well-digested Proceedings, which were chiefly prepared by him.

All these duties were executed with a fidelity and singleness of purpose, an ability, and a consummate knowledge of the whole subject confided to him, which entitle him to our deepest gratitude, and fully justify me in saying that our Transactions, Proceedings, and Collections of the last fourteen years are the real monuments of Mr. Lonsdale's labours. Alas! such efforts are more than one man can continuously sustain; and the loss of health which ensued, compelled our Curator to sever those ties by which he had been connected with us.

It is not, however, to official duties only that I must now advert; for the various works of Mr. Lonsdale, also published during the same period, prove clearly how much science might have received at his hands, had they not been bound by the trammels of official duty. His new arrangement of certain strata in the Oolitic series,—his important and original suggestion of the existence of an intermediary

type of Palæozoic fossils, since called Devonian,—and his masterly description of the Silurian Corals, are alone sufficient proofs of the vigour and accuracy of his researches. Placing in him the most entire confidence, and committing to his use, for a season, the proceeds of the Wollaston fund, this Society was amply repaid by the elaborate survey of a long range of the oolitic escarpments from the south-western country, with which he had long been familiar, to the Humber—a survey, from which, I venture to say, Sir Henry De la Beche will derive the greatest advantage, when he turns his attention to these districts, in a large portion of which the boundaries of the different oolitic formations were laid down upon the Ordnance Map by Mr. Lonsdale.

The enumeration of all these duties and labours—many of them of most difficult execution—still leaves unrecorded, what every working Member of this Society must feel, that in the secession of Mr. Lonsdale we have also lost our wise and friendly adviser on every obscure and difficult point. Who among the active promoters of our science has not derived from him willing and devoted assistance? How often, when balancing difficulties inseparable from our subject, have we not benefited by his sound opinions! And with what disinterestedness and real kindness were they not offered! Where is the memoir in our Transactions, or the separate works recently published by our Members, which has not been materially improved by his suggestions? In short, I am certain I speak the sentiments of all when I say, that, from the moment of his appointment to the day of his retirement, Mr. Lonsdale infused a truly generous and highly philosophic spirit into every act and every proceeding with which he was connected. No expression, therefore, of our gratitude can be too strong when we record his labours as a geologist, the value we entertain of his official services, and the pang of deep regret we experience in his retirement from this Society.

For a while the vacancy occasioned by the retirement of Mr. Lonsdale was not filled up; but the value which was attached to the office was attested by the fact, that nine candidates claimed our suffrage. The selection of Professor E. Forbes leads me naturally to report to you the principal geological results at which our new Curator has arrived during his recent researches in the Mediterranean seas, as they are distinctly connected with the

award of the Wollaston fund during a former year, to assist him in prosecuting his inquiries in the Mediterranean or Red Seas.

Mr. Forbes observed marine tertiary strata abounding in shells at an elevation of 4000 feet in the Lycian Taurus, and he fixed the age of two distinct tertiary groups in the Greek islands. He also determined that the freshwater deposits of Asia Minor and the Sporades belong to two separate groups, the relations of which with the marine tertiary strata prove that there were two eras of submergence and elevation, in that region, during the Tertiary period. He instituted a careful comparison between the organic remains of these beds and the living inhabitants of the adjacent sea, noticing the conditions under which each are found, and thus learnt that in the newest of these tertiaries (Newer Pliocene), the remains of such species as have ceased to exist in the Mediterranean are, for the most part, at present living in the Red Sea and Indian Ocean; and hence he very logically infers, that the former conditions of the Newer Pliocene period, which imply a similar and continuous submarine area, were interrupted by that elevation of land which separated the Egean and adjacent portions of the Mediterranean from the Red Sea, the faunas of which are materially distinct from each other.

Mr. Forbes explored a submarine tract of 300 miles in width, dredging in all depths between 1 and 230 fathoms. At less than 100 fathoms, the bottom often consisted of white chalky sediment, which extended throughout the Egean, and was invariably inhabited by the same species of Foraminifera. At a depth of 200 fathoms Mollusca only, of the genera Tellina, Corbula, Arca, and Dentalium were found, but associated with Annelides, Star-fishes, Crustaceans, and Zoophytes. Lastly, he ascertained the range and characters of 500 species of existing Mollusca and of numerous associated Radiata. Among the former were species which live indifferently at all depths between 10 and 150 fathoms, and several of them (including *Buccinum semistriatum*, *Dentalium quadrangulare*, and *Pleurotoma crispata*) which had hitherto been known only in a fossil state. By this examination he also arrived at the important fact, that such species as are abundant in a fossil are extremely rare in a living state, and *vice versâ*; and thus he lays before us the last remnants of a former state of the surface of whose existence we were ignorant, accompanied by the descendants of animals, which,

first appearing in small numbers in a pre-existing period, are now attaining their maximum of numerical developement.

Such discoveries, Gentlemen, are most important to the progress of true induction; and when these researches of Mr. Forbes are presented to you *in extenso*, as is his intention, each of us will, I doubt not, find in them some illustration of the stony deposits with which we are more familiar.

I may well, therefore, congratulate the Society on having obtained the services of such a naturalist as Mr. Forbes, of whom it has been said by a distinguished foreign contemporary, that "his anatomical knowledge, the accuracy of his thought, and the vigorous precision with which he can estimate the minute differences on which the distinction of species depends, render him a worthy successor of Mr. Lonsdale, and ensure to us that he will render important services to the advancement of Geological Science*".

Having spoken of those changes in the Society which have taken place through the demise of Members and through official changes, I now proceed to consider the progress of our Science, not merely within the British Isles, but also, as far as I am able, in other parts of the world to which geological researches have been extended. In so doing I shall follow the arrangement of last year, and treat of the rocks of each country in the order of their antiquity, commencing with the most ancient. First dwelling upon the British Isles, I will next advert to Russia, the Caucasus, Asia Minor, Turkey and the Alps, and then in succession to works upon America, the East Indies and Egypt; and after an analysis of the recent progress in Palæontology, I will take leave of you with a brief *résumé* of the principal geological results.

PALÆOZOIC ROCKS OF THE BRITISH ISLES.

Silurian Rocks.—In the Address of last year I plainly expressed my belief, founded not merely on researches in the British Isles, but also on examinations of large portions of the Continent, that the Lower Silurian group contained the most ancient fossiliferous type. This view now rests upon still firmer support, established by the labours of our geologists at home, and the doubts respecting the

* Professor Agassiz, Letter to Mr. Murchison.

true zoological base of the Palæozoic rocks have been entirely dispelled. In South Wales this point has been worked out with extraordinary fidelity of research, founded both on geometrical measurements and a close search after fossils; and to these investigations I will presently advert, when speaking of the labours of Sir Henry de la Beche and his assistants of the Ordnance Geological Survey.

In illustration of the structure of the Lake Country of the North of England, Professor Sedgwick has recently given a short sketch in three letters addressed to Mr. Wordsworth; and I beg you to consult this little work, which is embodied in a Guide to the Lakes published by his friend the celebrated poet, both as a specimen of the author's vigorous style of communicating popular geological knowledge, and to obtain from it a clear general perception of the configuration of that remarkable region, and of the changes it has undergone. In regard to the older Palæozoic rocks, referring to a memoir which he read before this Society in 1832, he still adheres to the threefold division of the slate-rocks of Cumberland proposed by Mr. Jonathan Otley. With the two lowest of these, the Skiddaw slate and the green slate and its associated porphyry, we need not now concern ourselves, for they contain no organic remains. The third division, or the Upper Slaty rocks, is considered by Professor Sedgwick to represent the Silurian series. He separates it into three groups, the uppermost of which he compares with the Ludlow rocks, the second is an ill-defined hard siliceous mass, with no good fossils, and the lowest consisting of the Ireleth slate and limestone, including the Coniston, is proved by its fossils to be of the age of the Lower Silurian rocks. This view is, in short, that which has been for some time entertained by Professor Sedgwick*, and is essentially the same as that taken by Mr. James Marshall.

During the preceding year our attention was also attracted to the district by the labours of Mr. Daniel Sharpe, who had commenced a more detailed inquiry into the subdivisions of this series. He has since presented us with the results of additional researches made during the last summer, which have led to some corrections of the Map formerly prepared, and to some changes in lines of fault as well as in the order and subdivision of the stratified masses. Describing

* See Proceedings Geol. Society. Vol. iii. p. 545, et seq.

the formations in ascending order, he enumerates several additional Lower Silurian fossils as occupying the Lower Coniston limestone with its overlying series of shale, slate and flagstone; and he amends the arrangement which he proposed last year, by also including in the Lower Silurian division certain grey slaty greywacke grits which he had left in the undefined group called by him "Windermere Rocks." Another bed of limestone, that of Blawith, which Mr. Marshall had also shown to contain organic remains of the Lower Silurian type, is stated by Mr. Sharpe to underlie the Ireleth flags and slates; and he considers all this series, from the Coniston Lower limestone upwards, to form the representative of the Lower Silurian rocks, in which the Kirkby Ireleth slates are included; not from any fossils they contain (none having been found in them), but because they are strongly affected by a slaty cleavage, and though invariably conformable to the other Lower Silurian beds, are not equally conformable to those above them. After tracing the demarcation of these slates, Mr. Sharpe then adverts to the fine developement of the Lower Silurian rocks in High Furness (Lancashire), where the formation has a north-easterly and south-westerly strike, in perfect parallelism with the ridges and valleys, which direction is strongly contrasted with the outline of the same rocks in Westmoreland and among the lakes, where the valleys are in the line of extensive faults, transverse to the strike; and it is in this region of greater disturbance that the rocks are in the most crystalline state (slaty cleavage, &c.). The Windermere rocks having been deprived, as above stated, of their lower member, by the admission of our author, and having been found to contain a species of Orthoceratite unknown in the Lower Silurian rocks, it is I think now more than ever probable* that they represent the Wenlock shale of the Silurian region; the more so as, resting on a great thickness of admitted Lower Silurian rocks, they are surmounted by unequivocal Lower Ludlow rock. In working out the exact relations of the Ludlow rocks of Westmoreland to those of Shropshire and Siluria, Mr. Sharpe has very considerably added to his memoir of last year, both by the addition of many species, and by distinguishing the Upper from the Lower Ludlow rock by fossils peculiar to each; and from what I know of the value of the *Terebratula navicula* as a guide, I

* See Discourse of last year.

completely approve of the arrangement, by which all the strata containing that shell are considered to be Lower Ludlow rocks.

It is indeed very remarkable, that a tract containing so little calcareous matter as the neighbourhood of Kendal, where the Lower and Upper Ludlow rocks, including in the latter the red tilestones, are strikingly displayed, should have afforded so many as eighty species of fossils which are identical with those published from the same formations in the Silurian region. Having myself visited this tract for the second time, and since Mr. Sharpe completed his last survey, I am sure he will unite with me in expressing the great obligations of all southern geologists like ourselves to the indefatigable industry and quick eye of Mr. John Ruthven of Kendal, who is the great purveyor of fossils both from the Silurian and Carboniferous rocks of the neighbourhood of his native place, and who, contributing largely to the Museum of Kendal, so ably directed by two gentlemen of that town *, is acquiring for himself a reputation in the North scarcely inferior to that which has been assigned to Miss Mary Anning in the South. The general conclusion of an independent and close observer like Mr. Sharpe cannot but be very gratifying to myself; for in stating that in mineral characters these Northern rocks differ most materially from those of Siluria, he points out that in each district the principal divisions of the Silurian system are distinctly maintained.

Transferring our view from the Lake Region to North Wales, we there find Mr. Sharpe applying the knowledge he had acquired in the Northern districts. In his memoir on the Bala limestone he shows, that, since that rock and its associated strata contain the same fossils as the Coniston limestone, it is of the Lower Silurian age and not Upper Cambrian, as it was formerly named. He is not however content with merely instancing a similarity of fossils and lithological succession in the Bala rocks, as compared with other well-known Lower Silurian strata, but he also proves by a transverse section, that they occupy a trough, supported on one side by older nonfossiliferous schists (part of the Berwyns) and on the other by igneous rocks (Arran Mowddy).

I am not prepared to oppose the accuracy of Mr. Sharpe's section; but when he quotes me as having stated that the Bala lime-

* Mr. Gough and Mr. Danby.

stone dips under the chief mass of the Berwyn mountains, I must be allowed to state, that I visited the locality but on one occasion, with Professor Sedgwick, and the limestone beds which I then saw seemed to me to be overlapped by the Berwyn rocks upon the east. Mr. Sharpe has no doubt accurately examined the whole territory around Bala, for he states that the limestone, of which there are two bands, is on the whole thrown off from the Berwyns with a westerly dip*, and is again brought up on the edges of Arran Mowddy with an easterly and south-easterly inclination. In another section, from the head of the lake of Bala to Dinas Mowddy and Mallwyd, he proves that these Lower Silurian rocks, folding over to the east and south, are surmounted by Upper Silurian strata. The whole descending series beneath certain dark blue slates, referred to the lowest part of the Upper Silurian beds, consists of an upper limestone, rotten schist, a second Bala limestone, grey slaty grits, rotten grey clay-slate, and dark blue slate. In all these beds, with the exception of the two lowest, Mr. Sharpe has discovered fossils; and in addition to well-known British Silurian forms, including the Trinuclei, so characteristic of the Lower Silurian rocks, he has discovered the *Illænus crassicauda*, a Trilobite, eminently characteristic, I would observe, of the inferior strata of the same age in Scandinavia and Russia. The beds of this group are stated to rest against an unconformable mass of clay-slate forming a portion of the Berwyn chain; and to this rock, which is void of fossils, and all that lie beneath it, our author would restrain the application of the word "Cambrian."

This reasoning is clear, but the author must excuse me if I remind him that no definite base-line of the Palæozoic rocks can be established by one transverse section only, which terminates in the centre of a very complicated region. He must know, that deposits which have no existence in a given territory set on and expand in adjacent tracts. Although, then, the structure of the Lake Country naturally gives him confidence in defining the base of the Silurian system by the comparison of the Bala rocks with those of Coniston, still it remains to be proved, whether the north-western tracts of North Wales do not contain other fossili-

* Professor Sedgwick still contends that the chief band of Bala limestone dips to the east.

ferous bands inferior to those of Bala. As Mr. Sharpe has not examined this part of the country, the question must be answered by others; and I rejoice to say that the reply is about to be made by the geologist, who, above all others, is most conversant with that region.

You are aware, Gentlemen, that this is the very tract in which Professor Sedgwick has so long worked, and from surveys of which he gained that intimate knowledge of slaty structure, which is now considered, thanks to his masterly memoir, an essential element in practical geology. I dwell upon this point with peculiar pleasure, because I well recollect the day when the truth of those lessons, which I first learnt from my friend, were opposed by many and accepted by few, though they now form part of the text-book of the field surveyor. To a re-examination of this country, then, Professor Sedgwick has devoted portions of the two last summers, with the distinct object of ascertaining, first, whether he was correct in his original opinion, on which I steadily relied, that great masses of the slaty rocks of North Wales, sometimes containing fossils, dipped under the Silurian rocks described by myself; and if so, secondly, what zoological distinction could be established between such rocks and those described as Lower Silurian. We were both aware, and the point was fully commented upon in my own work, that the Bala limestone fossils agreed with the Lower Silurian*; but depending upon his conviction that there were other and inferior masses also fossiliferous, we both clung to the hope that such strata, when thoroughly explored, would offer a sufficiency of new forms to characterize an inferior system. The results of Professor Sedgwick's recent researches would have been communicated to the Society before this Anniversary, had not his other avocations prevented his visiting London; and as the memoir will shortly be read before you, I will now so far allude to it only as to enable us to draw conclusions respecting the base of the fossiliferous slaty rocks of North Wales.

Professor Sedgwick has reassured himself that there are fossiliferous slaty masses, of great vertical thickness, which rise out from beneath the lowest Silurian rocks of North Wales hitherto described, and occupying the region of Merionethshire and Snowdonia, ultimately rest upon chloritic and micaceous schists (Menai Straits),

* See Silurian System, p. 308.

into which they do not pass. The lowest of these fossil bands, forming the summits and flanks of Moel Hebog and Snowdonia, are, he conceives, several thousand feet below the Bala limestone.

The hope, however, which was entertained by my friend, of finding these vastly expanded and lower members characterized by peculiar groups of fossils has been frustrated, and whatever may be the thickness of this lowest palæozoic division, in which he has collected a great number of species, he now fully admits, that zoologically it is from top to bottom a Lower Silurian series*. Charged as it is with characteristic Orthidæ and Trilobites, including the *Asaphus tyrannus*, so characteristic of the lowest Silurian rock, there are, as might be expected, a few new and undescribed species; and, among these, an Ophiura (an animal whose remains had not previously been found in strata of higher antiquity than the Lias) will not appear the least extraordinary.

The base of the palæozoic deposits, as founded on the distinction of organic remains, may now therefore be considered to be firmly established; for the Lower Silurian type is thus shown by Professor Sedgwick himself to be the oldest which can be detected in North Wales, the country of all others in Europe in which there is a great development of the inferior strata. But if classification is settled, there still remains much to be done before North Wales can be as accurately laid down upon a map as the parts of South Wales to which I will presently allude; though when the operations of the Ordnance surveyors are extended to this complicated region, we shall learn, by distinct geometrical admeasurement, the exact thickness of these subcrystalline rocks on the flanks of Snowdon.

In reference to the terms Caradoc Sandstone and Llandeilo Flags, as occasionally applied to the divisions of the Lower Silurian rocks, I must express my dissent from a proposal made by Mr. Sharpe to strike out one of these names from British nomenclature. He believes from what he has seen, that on the whole the type is the same throughout all these lower rocks; but I think Mr. Sharpe would not have offered this suggestion had he surveyed the whole of the Silurian region. If, for example, he had commenced his researches where Sir Henry De la Beche has been accurately fixing

* See an expression of the same opinions, Geol. Proc. vol. iii. p. 5. p. 549.

the limits of each formation, he would at all events have admitted the value of the term of Llandeilo flags, which the Director of the Ordnance Survey has informed me he considers to be a remarkably clear and well-defined formation, having a thickness of between 2000 and 3000 feet, and to be plainly separated from the Caradoc sandstone. If Mr. Sharpe supposes that by such a term as Llandeilo flags, I intended to restrict this or any other formation to a mass having one mineral character only, he has misapprehended my meaning, and I refer him to a description of the strata, as seen between Llandeilo and Llandovery, where sandstone, schist and limestone, occurring in repeated alternation, form the "Llandeilo flags." In the first years of my researches in the Silurian region, I was for a moment induced to think, that it would be better to merge the two lower formations under one local name; but the clear sections of South Wales, and those on the eastern flanks of the Berwyns, where the slaty calcareous rocks with large Asaphi are seen to dip under great masses of Caradoc sandstone, confirmed me in the resolution to adhere to the two local names. I trusted that as detailed surveys were made, the truth of their relations would be confirmed (under those limitations which are common to all deposits): whilst in the tracts where the calcareous matter thins out, and no clear lithological or physical differences exist, I urged that the whole of the inferior type should be distinguished from the Superior by the name of Lower Silurian. I have myself, therefore, provided for the cases when the local types are merged; but I am glad they were proposed, because they have already served as useful horizons for the labours of the Ordnance Geological Survey, to which I now call your attention.

Ordnance Geological Survey of England.—The progress which was confidently expected at the hands of the Ordnance Geological Survey, directed by Sir Henry De la Beche, has recently been so effectively extended to a country with great part of which I am well acquainted, that, whilst we are considering the subject of the Palæozoic Rocks, I take the opportunity to add my tribute to the large share of public approbation which such labours must earn for their authors. If my few comments on this subject involve reference to my own work, I trust the Society will believe that such allusions are made solely to explain the subsequent progress of other geologists.

In my last Address I alluded to the valuable researches of the Ordnance Geological Survey in South Wales, particularly in the great coal-basin; and I have now to speak of them amid the older rocks of Pembrokeshire and Caermarthenshire, forming the south-western tracts of the country termed the Silurian region. In the survey of that region, my chief object, as you know, Gentlemen, was simply to ascertain the general classification and right order of certain fossiliferous strata beneath the Old Red Sandstone. Having worked out the succession in typical districts in Shropshire, Herefordshire, Radnor and Montgomeryshire, I afterwards traced them to the south-west, until I equally determined their relations to the superior deposits in the coast-sections of South Wales. Although the labours in the latter country were thus auxiliary only to those of the arena on which the classification was established, I have had great satisfaction in finding, that my chief boundary lines of Old Red Sandstone and Upper and Lower Silurian Rocks are pretty nearly those which have resulted from the very systematic Ordnance Survey, the first corrected field-sheets of which Sir H. De la Beche has allowed me to view. This observation has reference only, however, to the development of what may be called one zone of Silurian rocks, or that to which, as contiguous to the Old Red Sandstone, I gave my chief attention. Of the existence of true Silurian rocks to the west and north of a certain line which was set up as a descending limit in South Wales, I was, I confess, entirely ignorant. Finding no fossils in the few visits which I made to the west of that barrier in Caermarthenshire, which was provisionally agreed upon, and to the north and west of which all the country was ultimately to be explored by my friend Professor Sedgwick, we both of us believed, that such tracts, for the most part without fossils, were of higher antiquity than the Silurian districts, and that, rising up from beneath, they might hereafter be found to contain other and distinct forms of animal life.

The inquiry of Sir H. De la Beche has dispelled our ignorance. Instructing a number of intelligent young surveyors how to apply trigonometrical mensuration to stratified rocks, and patiently following up each mineral mass through its change of conditions upon its strike and throughout every contortion, the Director of the Survey has now clearly ascertained that the rocks to the north and west

of the Towey in Caermarthenshire, as well as those to the north of Haverfordwest in Pembrokeshire*, instead of being an undefined assemblage, to which the term Cambrian had been applied, are in truth nothing but the very same Lower Silurian rocks which had been pointed out on the east and south, and which (the Llandeilo flags being much more important than the Caradoc sandstone) are repeated in great folds and undulations to the north and west. Often parting with their calcareous matter, these strata, often assuming a crystalline slaty cleavage, are in some tracts highly altered by the intermixture of trappean rocks, both of contemporaneous origin and subsequent intrusion. But in these altered rocks the Ordnance surveyors have detected true Lower Silurian fossils, and have thus, by zoological evidence as well as by geometrical admeasurements, convinced themselves that the rocks so very different in aspect, are nothing more than repetitions of the same fossiliferous strata which have been described upon the south and east. Such results, obtained amid strata so obscured by change, is one of the very highest triumphs of geological field-work; and I therefore wish to be foremost in recognising the deserts of the labourers who have obtained them, among whom the Director particularly cites Mr. Ramsay, already so favourably known to us by his geological map and model of the Isle of Arran.

In looking at the Ordnance Maps of North Pembroke, which have recently been coloured, and will shortly be issued to the public, it is surprising to see how symmetrical order has been obtained out of such a labyrinth, and how the fragments and pieces of such a patch-work are brought together. I have the authority of Sir H. De la Beche to state, that in some districts the convolutions are so rapid as to reproduce the same band of contemporaneous trap, in perfectly parallel lines, no less than ten or twelve times in the width of a mile, whilst bosses of eruptive trap are so numerous as to defy analytical research. Although I only passed quickly over the tract of North Pembroke, and ought therefore, never to have added it to those portions of my work which were more carefully executed, I have still sufficient recollection of it to admire the beauty of the new delineations. If I may be allowed to suggest a parallel between it and districts which I have more mi-

* See Observations in Address of last year on Mr. M'Lauchlan's researches.

nutely described, I am greatly mistaken if North Pembroke does not present phænomena almost completely analogous to those of the mineralized Lower Silurian rocks north of Builth in Radnorshire, and at Cornden and Shelve in Shropshire, where numerous lines of contemporaneous trap alternate with Llandeilo flags and Caradoc sandstone, and where the strata on the flanks of eruptive rocks are the seats of lead and copper ores, the sandstones being often converted into quartz rocks (Caradoc, Stiper Stones, Wrekin, &c. &c.). Combining the evidence of these tracts with those laid open by the extensive transverse sections which I formerly made in Montgomeryshire, in the north-western parts of the Silurian region, where the masses have been shown to roll over in great undulations from S.E. to N.W., I am fully prepared to admit the existence of a similar configuration in North Pembroke, West Caermarthenshire and Cardiganshire, districts with which I was very imperfectly acquainted, and where the aspect of rocks is at first sight, it must be admitted, very forbidding to those who search after fossil evidences. The greater, however, the difficulty, the greater is the merit of those who have solved the problem, and have thus established in parts of South Wales the precise relations of what were previously considered to be anomalous masses. The result of this Survey, up to the present moment, is, that in one small part only of North Pembroke is there any development of rock older than the strata containing Lower Silurian fossils, and this occurs in the promontory of St. David's, with which I am familiar: this rock, I can confidently say, is mineralogically undistinguishable from the close-grained purple greywacke of the Longmynd and Haughmond Hill in Shropshire; and in both these localities it has hitherto been found as void of fossils as in the similar rocks of the Lammermuir Hills in the South of Scotland.

In the south-eastern parts of the Silurian region, to which the Ordnance Geological Survey has also extended its labours, the accuracy of the chief lines which had been laid down, whether in May Hill, Usk, Woolhope, and the Malvern Hills, has been confirmed; and, under the vigilant eye of Mr. Phillips, some new species have been added to the former lists, both in the Lower and in the Upper Silurian rocks. Among the latter the *Pentamerus Knightii* has been found in a new locality, in the southern prolongation of

the axis of Woolhope, thus showing how persistently the place of the Aymestry limestone is maintained; whilst a species of that remarkable shell, the Pleurorhynchus, has been detected in true Wenlock limestone.

In relation to the west flank of the Malvern Hills, Mr. Phillips has, by very close researches, come to an important conclusion. Certain specimens of a peculiar conglomerate or breccia having been found by his sister Miss Phillips, in which the *Pentamerus lævis* and other Caradoc fossils are associated with fragments of syenite, a further search was instituted, and a small boss of this rock was laid bare on the very edge of the syenite and in a vertical position, like most of the beds of the same formation along the north-western prolongation of these hills. The conclusion drawn by Mr. Phillips is, that a portion at least of the crystalline Malvern chain was in existence when the Caradoc sandstone was formed, an inference which is strengthened by the finer-grained adjacent and regularly-bedded varieties of the sandstone containing similar minutely triturated, igneous materials. At the same time it is certain, that the great upheavals of the syenite and trappean rocks took place long after the deposition of the Silurian strata, and even after that of the old red sandstone and coal-measures, which at various points along this ridge, and particularly at the Abberley Hills, have been violently dislocated in contact with such intrusive rocks. The discovery on the west of the Malverns is, however, analogous to what has been observed along the flanks of the granitic axes in the Highlands of Scotland (Ord of Caithness, &c.), where fragments of rocks derived from them are imbedded in the old red sandstone conglomerates, thus showing an original crystalline nucleus, followed by other granitic eruptions. The Isle of Arran offers proof of such a period of activity, which it has been inferred, was posterior to the contiguous red conglomerate, in which no granitic fragments are imbedded.

When he pursues his researches to the northern parts of the Silurian region, Mr. Phillips will then see, on the flanks of the Breidden Hills, evidences nearly analogous to those which he has so well described in the Malvern Hills, and where it has been shown, that along a very ancient fissure of eruption, molten matter was consolidated before the existence of the Silurian rocks; that

other eruptions followed, and were in continuous activity during the formation of the Lower Silurian strata; that again other upheavals took place by the rise of intrusive trap, which threw the previously-formed contemporaneous plutonic deposits upon their edges; that the coal-measures deposited unconformably on such uplifted strata were afterwards deranged; and finally, that along the very same line of eruption, igneous matter, undistinguishable in mineral composition from that which had affected the ancient rocks, has cut its way in irregular dykes through the new red sandstone, and, from the isolation of a deposit of lias, was probably ejected subsequent to the accumulation of that deposit*.

Such facts are, it seems to me, miniature counterparts of the upraising at successive periods of mountain chains; and the grand phænomena of the Caucasus, the Alps, and the Pyrenees may nearly all be studied in our small English ridges, and some of them peculiarly well upon the flanks of the Malverns, and their continuation the Abberley Hills.

In the sequel I shall have occasion to speak of other important researches of Mr. Phillips. For the present, then, I take leave of the Ordnance Geological Survey, assuring this Society, that having during the past year, for the first time, seen the practical application of the admirable method of field-survey which has been instituted by Sir Henry De la Beche, I am convinced that it will not only act directly as a great national benefit, in making more correctly known the structure of the subsoil, in a manner beyond the reach of private enterprise, but that it will materially tend to elevate Geology, by connecting it in a permanent manner with Physical Science.

Rocks of the Scottish Border.—A memoir by Mr. W. Stevenson on the Geology of Berwickshire appears to me to be worthy of commendation, from the perspicuity with which he treats a difficult subject in this his first production. In consequence of a notice in the work of Mr. Hugh Miller on the Scottish Old Red Sandstone, that Mr. Stevenson had discovered ichthyolites in that rock near his native town of Dunse, I made an excursion thither during the last summer, from the east coast of Berwickshire, which I was examining in company with my friend Count Keyserling. Having visited the localities of the Old Red fossils, and made the acquaintance of Mr.

* See Silurian System, p. 294.

Stevenson, I perceived that he had clearly worked out the leading phænomena of the border country, and I therefore urged him to prepare the paper which has been read before you.

Notwithstanding the memoirs of Mr. Winch, Mr. N. Wood, and Mr. Witham, on the Carboniferous rocks of Northumberland and the borders, and of the excellent work of Mr. D. Milne on Berwickshire, no portion of the British Isles more required surveying, than the tract on both sides of the river Tweed, from its mouth upwards. The very clear section laid open by lowering the high road in its descent from Belford to the town of Berwick, had, it is true, completely satisfied every one who had seen it, that of the Berwickshire coal-seams (seven of which are worked), some are subordinate to the lowest beds of the mountain limestone series, and that others are far below it. Having confirmed the views of Mr. Witham, my fellow-traveller and myself worked out this point further, by following the coast from Berwick northwards to Bourne Mouth, and by ascertaining that the coal-beds beneath the Lamberton Cliffs (and others are still lower) are at considerable depths under the lowest band of limestone, containing Producti and shells of the carboniferous limestone; in short, that they form part of a red sandstone group, in which the plants of the Carboniferous system prevailed. Unluckily, the regular descending sequence from these lowest *red* coal-fields into the deposits of old red sandstone, properly so called, has not yet been noticed on the sea-coast, nor is it probable that such passage can there be detected, owing to a great dislocation which has thrown the lower carboniferous strata into a vertical position against metamorphic greywacke and trappean rocks.

Unacquainted with these coast-sections, Mr. Stevenson has, however, made out in the interior, and from comparatively obscure data, a natural ascending succession from the nonfossiliferous slaty rocks of the Lammermuir Hills, through the old red sandstone, to the base of the productive coal-field above alluded to. The old red sandstone which reposes on the Lammermuir rocks, and is frequently a coarse conglomerate, contains the scales of Holoptychius; and at a little distance in the direction of the dip, other and newer beds are loaded with impressions of plants, probably marine. Red and greenish-white sandstone and argillaceous red strata are followed by impure concretionary limestone, termed corn-stones by our author,

and these pass upwards into sandstones and shale, enclosing plants peculiar to the Carboniferous system. Occupying a great breadth in the county of Berwick, and for the most part unproductive in coal, some of these bands being of red colours, and containing gypsum, were formerly mistaken for the new red sandstone. So long as a too strict adherence to lithological characters, as decisive of the age of formations, prevailed, doubts were thrown upon the age of the Berwickshire coal-field; for notwithstanding the memoir of Mr. Witham, which distinctly showed that a part of this great red coal-field lay beneath the mountain limestone, and contained many species of true carboniferous plants, the influence of the red and gypseous characters of this deposit was all-powerful. The correct view, however, has been maintained for some years by Professor Sedgwick and several other geologists.

Taking our earlier views chiefly from the English southern coal-tracts, and not sufficiently attending to their far greater development in the northern counties, we have been apt to force the larger into too strict accordance with the smaller type. Geologists, therefore, who are well acquainted only with the carboniferous succession of Bristol and South Wales, must now learn, that the lower limestone shale of these tracts (oftentimes indeed a sandstone) is the miniature representative of the enormously thick and varied carbonaceous deposits of the South of Scotland. I may say of Scotland, for it is quite evident, that some of the most productive of the coal and iron-stone fields (many of them associated with much red sandstone) in the centre of that country, occupy precisely the same horizon; their upper masses being interlaced with thin calcareous courses in which mountain limestone fossils prevail. I shall revert to this subject in alluding to a recent work of Mr. Griffith on the Geology of Ireland, where the lower part of the carboniferous system is enormously developed.

In reference to Mr. Stevenson's effort to class the fossil beds of the Old Red Sandstone near Dunse, I would observe, that we can scarcely hope to separate this formation into all its true divisions, by the aid of a very few scales of one or two species of fossil fishes only. In Russia, for example, the very highest beds of the system —beds absolutely in contact with overlying carboniferous strata, are

loaded with the *Holoptychius nobilissimus*; whilst in the same region, strata, infinitely lower in the series, are charged with the *Dendrodus strigatus* and other forms which are associated with the *Holoptychius nobilissimus* in the very same stratum at Scat's Craig, near Elgin.

Describing the dislocations around Dunse, Mr. Stevenson connects them with trappean dykes, and sustains the original view of Mr. D. Milne, that the Lammermuir chain has undergone two distinct upheavals; one marked by the felspathic nature of the igneous masses affecting the older greywacke; the other by the augitic nature of the trap which has pierced the old red sandstone and coal-fields, and thrown them into discordant positions. Thus, whilst he indicates faults which traverse the whole series, he also demonstrates, that the masses of granite which intrude upon the older felspathic trap, have produced no alteration in the overlying red sandstone; the latter in fact having been deposited upon those rocks of earlier disturbance, fragments and pebbles of which are included in the red sandstone matrix, and even in the basaltic matter which has been the cause of the second great elevation of the tract.

This reminds me of an old observation of Professor Sedgwick on the flanks of the Cheviots, where he discovered that the old conglomerates at the base of the lowest carboniferous strata of Northumberland are almost made up of Cheviot porphyry; and that where the coal strata north of Berwick are set on edge, and in one place inverted, there are dykes and masses of a newer augitic trap.

Irish Ordnance Geological Survey—Tabular List of Irish fossils.—A compendious volume, entitled 'A Report on the Geology of Londonderry, and parts of Tyrone and Fermanagh,' has just been published by our associate Captain Portlock, R.E., employed in the Irish Trigonometrical Survey. Illustrated by a geological map, numerous coloured sections, and plates of organic remains, this closely packed volume, of nearly 800 pages, is a sample of how great a mass of matter may be derived from a small district. Not having had sufficient time to study the details of this work, I must crave the author's indulgence if I refer only to such parts of it as have arrested my attention. Captain Portlock, having some time ago discovered a small patch of Silurian rocks in the region of his official labours, commenced a careful and systematic inquiry into the

nature of the Trilobites with which it seemed to abound, and he now presents us with some very valuable results. In a preliminary discourse he offers many important remarks upon the affinities and anatomy of this group of animals, and after a very elaborate comparison of all the forms which he could detect in his district with those published by British and foreign authors, citing among the latter several works very little known to us, he arrives at the conclusion, that of sixty species in this palæozoic tract, fifty-two belong to true Silurian strata (for the greater part Lower Silurian), and eight only to the enormously developed carboniferous limestone of the North of Ireland. This fact is quite in accordance with what has long been my belief, that the Silurian or oldest palæozoic group is the great centre of Trilobitic life. Describing many new forms, which are figured, he establishes several new genera, among which the Rhemopleurides, obtained from the Lower Silurian rocks, is a very curious and apparently quite distinct trilobite. There are but small traces of Upper Silurian or Devonian deposits in this district, the greater part of it being covered by a carboniferous series, consisting, as the mountain limestone of Ireland is known to do, of much sandstone and slate as well as limestone. Finding in it several shells which are eminently characteristic of the lower as well as of the upper beds of that great formation, he infers, and I think with perfect justice, that the mountain limestone of the North of Ireland must be compared with the whole and not with the upper part only of that formation in the North of England; an opinion I am prepared to support, by having found last summer several shells (notably the *Sanguinolaria undata*), which are published by Captain Portlock from the north of Ireland, in the very bottom beds of the limestone of Berwickshire and Northumberland. Confining myself to the researches of this author in the palæozoic rocks, on which he has shown so much skill, I must also request my hearers to consult this volume of the Irish Geological Survey, for much information respecting the overlying strata, among which some new features of the Keuper formation are sketched with the author's usual fidelity.

From the researches of Captain Portlock I turn to those of Mr. Griffith, who spent many years in preparing the Geological Map of Ireland, and for which he has deservedly received much

praise. In a very elaborate comparative table of the fossils of the mountain limestone series of Ireland, presented to the Manchester Meeting of the British Association, Mr. Griffith divides that series into five subformations, which in ascending order are the Yellow Sandstone, Carboniferous Slates, Lower Limestone, Calp, and Upper Limestone. He also shows that the two lower of these subdivisions must, from their fossils, many of which ascend into the overlying strata, be classed with the mountain limestone series, and not with the Devonian rocks; in which case, I would observe, that they must also be classed with the sandstone, limestones and shale of Berwickshire, to which allusion has already been made. I am the more induced to believe in the accuracy of this comparison, because Count Keyserling and myself have this year confirmed the observation of Professor Sedgwick, made in 1828,* viz. that Posidoniæ, similar to those in the culm limestones of North Devon, exist in the middle of the mountain limestone series of Northumberland. As Mr. Griffith has shown that the Irish Calp, which also occupies the middle place in the limestone of Ireland, contains the same peculiar fossils, the parallel may now be considered as very well established, between this central mass of the mountain limestone in these distant localities.

Drawn up as this table has been under the directions of Mr. Griffith, by a diligent young naturalist of good promise, Mr. F. M'Coy, there can be no doubt that it is entitled to much consideration, and that its publication will be very useful. In reference to the comparison instituted by Mr. Griffith between the strata of North and South Devon and those of Ireland, I may observe that it is of infinite importance to the establishment of a true series of equivalents, that large adjacent tracts of country should be surveyed, and their fossils compared by the same observers, for the want of which identical species may sometimes obtain different specific names; thus considerably interfering with a nice discrimination of the groups.

Palæozoic Fossils.—Before I quit the subject of the older British rocks, it is my duty specially to call your notice to a memoir just published in your Transactions, because, although inserted by order of the Council, and throwing great light on British palæozoic remains, it has not yet been sufficiently alluded to from this Chair. It is the

* See Professor Sedgwick and Mr. Murchison, Geol. Trans. vol. iii. p. 693.

work of MM. de Verneuil, and D'Archiac on the Fauna of the Palæozoic Rocks. In the first instance this memoir was designed to consist simply of a description, by M. E. de Verneuil, of the organic remains of the Rhenish provinces explored by Professor Sedgwick and myself, and of which you have now our published views. M. De Verneuil, who combines the attainments of a good conchologist with those of a geologist, had accompanied us during a part of our survey of that region, and approving the general classification, had kindly offered to illustrate our views by the use of the very fine fossils from the Rhine and the Eifel which his cabinet contained. While instituting the comparisons necessary to prove, by evidences independent of those in England, that the Devonian is a true intermediary type, the subject became enlarged in his hands, and he was so fortunate as to procure the assistance of his friend the Vicomte D'Archiac. By combining researches and making a variety of comparisons, their work soon acquired great value, not merely as regards an accurate description of beautiful organic remains, admirably lithographed, but as containing also a general tabular list of the fossils of the Devonian system in Europe, as compared with the species of the Silurian and Carboniferous deposits in the Rhenish provinces.

This table, enriched as it has been up to the moment of publication by additions drawn from recent researches in Russia, must be considered a standard acquisition, the intrinsic merit of which can only be estimated by those who are aware of the labour and range of study which its preparation required. Nor are the general views of the authors, which are embodied in their preface, less worthy of consideration, for they exhibit an intimate acquaintance with fossil zoology and its relations to each great system of the palæozoic rocks; whilst it must be satisfactory to British geologists, that the inductions of these foreign naturalists are in harmony with those of Mr. Phillips, drawn from his own observations upon the fossils of Devon and Cornwall. As this is the first occasion on which French geologists have presented to us a memoir illustrating the writings of our own countrymen, I am confident you will unite with me in thanking them most cordially for their liberal and enlightened assistance. Whilst considering the palæozoic classification established in Great Britain, I have, therefore, thought it not irrelevant thus to allude to the labours of foreign geologists which support it; and I

have the pleasure of acquainting you, that in addition to their claims upon us, MM. D'Archiac and de Verneuil have, during the last summer, explored parts of Normandy and Brittany, where they have clearly recognised in that obscure tract, the same palæozoic divisions as exist in the Rhenish provinces and the British Isles.

I cannot take leave of the palæozoic rocks of our own islands without communicating to the Society a fact, which minute as it may seem to be, is of interest in regulating our views respecting the development of animal life. The Rev. P. B. Brodie, to whose researches in the secondary rocks I shall presently allude, informs me, that he lately discovered in the Silurian limestone on the west flank of May Hill, Gloucestershire, two palates of fishes. Now as the rock in question is of the age of the Wenlock limestone, we learn that fishes existed in the inferior as well as in the superior member of the Upper Silurian rocks, in which they had previously been noticed. No trace, however, of Vertebrata has yet been discovered in the widely extended and enormously thick Lower Silurian deposits.

Igneous Rocks of South Staffordshire.—As connected with the older depositary rocks of the central counties of England, I will now direct your attention to some recent observations on the changes to which they have been subjected by igneous agency. Besides forming a most instructive museum, singularly rich in Silurian and Carboniferous species (including many unpublished), the Geological Society of Dudley, to the establishment of which I last year alluded, has produced a report 'On the Igneous Rocks of the South Staffordshire Coal-field*,' not yet printed, with the results of which I am convinced you will thank me for making you acquainted. In the southern portion of this coal-field there are centres of eruption where the basaltic and trappean matter, rising from the bowels of the earth, completely cuts through the surrounding carboniferous strata, dislocating and altering them in the manner which has been pointed out by Mr. Keir, Mr. Arthur Aikin, and other observers, including myself. In regard to the lateral injections of the igneous matter among the coal strata, Mr. Blackwell, by comparing the shaft-sections of contiguous collieries, has shown, that however a

* The Report to which allusion is here made, including the Sections, was drawn up by Mr. J. H. Blackwell of Dudley, assisted by Mr. W. Spencer.

single vertical section might seem to afford grounds for belief, that such igneous matter had been formed as a bed, yet that in reality it traverses various depositary strata in a slightly oblique direction, and often thins out in the form of a wedge. From such apparently horizontal masses, vertical dykes, with occasional lateral veins of white felspathic rock, varying in thickness from a few inches to three or four yards, are seen to rise up and traverse the coal-beds in the most irregular manner, though such dykes are not found to produce any derangement in the regular measures. Another good fact observed in relation to a supposed horizontal sheet of basalt in the midst of the sedimentary strata, is, that the beds on which it rests are less subject to faults and dislocations than those which lie above it; the intruded mass, indeed, sometimes rising up to the surface and forming a knoll, occasionally bare, and at other places covered by the coal strata, which mantle round it.

The report also proves, that some of the chief faults which radiate from one of the great centres of eruption (Barrow Hill), were produced contemporaneously with its elevation; since the basaltic matter which flows laterally in apparent beds, follows the line of fault, bending and leaping up, as it were, without a break from lower to higher levels. From this fact Mr. Blackwell infers, that the basaltic matter must have been in fusion when it was extruded laterally along the surfaces of certain strata, but that the subsequent dislocation by which these beds were moved to different levels, took place before the igneous matter had cooled and when it was still plastic. This very remarkable phænomenon, which is indeed similar to examples cited by Dr. Mac Culloch, is an exception to the cases in other parts of the district (Wolverhampton), where the beds of basalt are broken off and change their relative places with the coal strata; and thus we learn that in the same district the faults were not all produced at one period.

Near Wolverhampton, the underground trap, which is spread over an area of five miles by two, is to a great extent perfectly conformable to the coal-measures above and below it; but when traced for upwards of three miles, its nonconformity to the coal-beds becomes apparent, and this is further confirmed by the giving off of white vertical felspathic dykes, similar to those before alluded to. It is, however, worthy of record, that no centre of eruption has yet been

discovered in this part of the district whence the flow of basaltic matter could have been derived, though it is believed that it may have proceeded from the distant Rowley Hills.

After minutely elucidating the distinctions and the variations of structure and form in the various trappean rocks of this district, the report proceeds to point out the changes which have been produced in the coal-measures by their intrusion. The same beds of coal, which in parts of the field exempt from basalt are highly bituminous, are, when in contact or in the vicinity of that rock, either converted into anthracite or charred into cinders. In the Wolverhampton tract the upper portion of the coal beneath the greenstone is entirely cut out, whilst the lower part is converted into anthracite, and often fissured by vertical joints, accompanied by veins of calcareous spar; as if, in driving off the bituminous matter of the coal, the extreme heat had also occasioned a contraction of the carbonaceous mass. Besides these alterations of the coal, the beds of ironstone are equally affected, the clay being rendered porcellaneous, and the sandstones, usually much hardened, are in some cases even vitrified.

In addition to these changes, which are analogous to effects observed in other countries, and are such as a high degree of temperature will readily explain, other alterations are cited, with some of which, indeed, Mr. W. Matthews acquainted me when I examined the tract, and the solution of which is not so easy; viz. that beds slightly impregnated with iron at a distance from them, become gradually more charged with it as they approach the igneous rocks, and are of very superior quality in their immediate vicinity. This fact, indeed, is perfectly in accordance with what I have lately observed in the Ural Mountains, where masses of iron ore are crystalline and even highly magnetic when in contact with eruptive rocks.

Another point dwelt upon, perhaps still more curious, and which also requires the consideration of the chemist, is, that wherever igneous rock is present in the neighbourhood of beds of coal, and yet separated from them by an intervening substance, which has prevented their being injured by intensity of heat, the coal is frequently what is called "brighter and more bituminous!"

With such facts before them, the authors of this report are aware, that other agencies than those of mere heat, are required to account for the production of iron concretions and the crystalline struc-

ture of coal; but whilst they think that electric and magnetic currents must also have operated in bringing about some of the results, they are convinced that the presence of igneous matter, often extended laterally in the form of vast beds, must have had a great share in the production of such phænomena. Having myself taken no little interest in the formation of the Dudley and Midland Geological Society*, I hail this report upon the physical conditjon of the subterranean masses of that tract as worthy of the approbation of men of science in all countries; for the history of Dudley is that of many regions of the earth, which have been penetrated by intrusive matter.

Secondary British Rocks.

New Red Sandstone.—Our knowledge of the structure and contents of the uppermost member of the New Red Sandstone has been considerably increased by the researches of Mr. Phillips and the Ordnance Surveyors. In our Memoir of parts of Gloucestershire, Worcestershire and Warwickshire, Mr. H. Strickland and myself pointed out the existence of a peculiar bed of sandstone subordinate to the marls underlying the Lias, and we were led, on account of the fishes and shells contained in it, as well as from the footmarks of peculiar saurians and its geological position, to refer this rock and the associated marls to the Keuper formation of Germany and France. The more detailed researches of Mr. Phillips confirm this view, and show that the sandstone is far more continuous than was believed; winding with remarkable sinuosities over large areas, and characterized by peculiar fishes and other fossils. With such clear types to guide them, the Ordnance surveyors will, I trust, be able, as they move northwards, to show the exact line of separation between this deposit of Keuper marl and sandstone, and the great masses of inferior red and yellow sandstone, which extending from Warwick northwards, occupy large portions of the central counties, and expand into the great formation on the banks of the Mersey, so strikingly characterized by the footmarks of the Cheirotherium. These lower sandstones must, I contend, be placed on the parallel of the *Bunter*

* See Address to the Dudley and Midland Counties Geological Society, 1841.

Sandstein of the Continent, in which similar impressions occur, and can never be confounded with the upper marls and sandstone of the true Keuper*.

Lias and Oolites.—When we consider the number of years during which the oolitic system and the lias have been submitted to the researches of geologists, it might be expected that few or no new fossils remained to be discovered in them, but such is not the case. Whenever fresh investigations are made, undescribed forms appear, and of this we have just had a striking example in the neighbourhood of Cheltenham, where one of our members, Mr. Buckman, has collected a vast number of new species characterizing each stratum in the Lias and Inferior Oolite, and has published a most instructive tabular view, illustrating much more completely than myself, the order which I formerly pointed out to this Society. He has in short detected many undescribed organic remains, throughout the series from the Lower Lias to the Stonesfield Slate inclusive, some of which will be figured in a new edition of the outline of the Geology of the neighbourhood of Cheltenham.

* Since this Address was read, I have been informed by my friend Dr. Buckland, that he has re-discovered among the mislaid treasures of his museum, certain saurian remains from Guy's Cliff to which much interest was attached, and that Professor Owen has pronounced them to belong to the species of *Cylindricodon* described by Jäger from the Keuper sandstone of Würtemburg. When Mr. Strickland and myself contended that the sandstone of Guy's Cliff and Warwick did not represent the Keuper, we did so from positive stratigraphical evidence, which proved that a thick formation of marl and sandstone was interpolated between the base of the Lias and the Warwick sandstone. We may, indeed, have been carried too far in saying that the discovery of the same species of saurian described by Jäger must determine the age of the rock; for we are not yet sufficiently acquainted with the distribution of the fossils of the *Trias*, to know whether some species may not be common to the whole of that group, and in England, where the muschelkalk is wanting, it is no easy matter to draw the line of zoological demarcation between the *Keuper* and *Bunter* sandstones. In the mean time it will be admitted, that Mr. Strickland and myself pointed out, for the first time, an upper stage in the series of the New Red Sandstone of England, which, containing peculiar organic remains, was proved to be distinct from the underlying masses of red sandstone (Warwick, &c.), and whatever may be the *names* attached to them, these two formations must henceforward be distinguished from each other in English geology.

And here, whilst speaking of detailed sections of the same formation in distant localities, I request my countrymen, who have studied this portion of the series, and who may travel through Germany, not to omit to visit the noble sections of lias exposed at Banz in Upper Franconia, to which I called your attention nine years ago, and which have since been grouped and described by M. Von Buch in his general work on the Jura formations. In mentioning this foreign locality, I specially recommend to your notice a detailed tabular view, by M. Theodori of Banz, of the strata between the Keuper and the Inferior Oolite. With one sandstone at its summit and another at its base, the great blue lias portion of the formation is separated into no less than forty-six bands, each of which is distinguished by either peculiar mineral or zoological characters, the upper portion being chiefly characterized by bituminous slaty marl, alternating with *Posidonia* and *Monotis* limestone; the middle mass by consisting of slaty clay and alum-shale with a great profusion of our well-known lias fossils; and the lower part by Gryphite limestone with its underlying shale and sandstone.

I have alluded to this detailed section, not only because I know, from personal inspection of the spot, that the author is well acquainted with the position of the numerous fossils which he cites, but also to impress upon you, that differing, as this section does, in lithological features from our British types of Lias, the agreement between the fossils of the two countries is very remarkable, a great number of species being identical with our published forms, whilst others are new. It remains, therefore, for good conchologists to ascertain how many of our British unpublished species are similar to the additional German forms; or otherwise confusion may be introduced by employing two names for the same shells.

The Rev. P. B. Brodie, to the value of whose minute researches I last year bore testimony, has since discovered insects, of which even the wings are sometimes preserved. He states that they are extensively developed in the bottom beds of the Lias through the Vale of Gloucester, an observation which he has rendered still more important, by showing that these creatures are associated with fresh-water remains and terrestrial plants mixed up with marine shells, or such, at all events, as inhabit estuaries; thus indicating the tranquil

transport of insects and plants from adjacent land, probably at that period, in the form of scattered islands.

In reference to one member of these deposits, the celebrated bone-bed at the base of the Lias, Mr. Strickland, in observing certain hitherto uninvestigated appearances on its surface, has employed the analogical reasoning of a naturalist accustomed to note the habits of the lower vertebrata. Some of these markings he has sought to explain by the action of fast-swimming fishes; others by mud-feeding fishes probing and turning up the surface, whilst narrow and angular grooves are referred to the movements of an acephalous mollusk, and fine tortuous tracks are supposed to have been caused by the crawling of small annelids. This latter point was previously adverted to by Mr. Atkinson*.

Wealden.—In enriching the fauna of the Wealden formation by a second discovery of a number of new species of insects in the Vale of Wardour, Mr. Brodie has again proved how much may be done by minute and careful researches, and has shown us how essentially our acquaintance with the former conditions of land and water depend on such information. He observes, that next to the Coleoptera, the most prevalent orders are the Homoptera and Trichoptera, the first of which now live on plants, similar to those found fossil in the Wealden, and the existing species of the latter hover over the surface of our present streams. From their broken condition he thinks it probable, that these insects were carried for some distance down rivers before they reached the estuary of the Wealden†.

Cretaceous System.—Passing from the Wealden, I must allude to two communications which this session has produced from Dr. Mantell, both relating to the Cretaceous system. In one of these he describes three species of fruit from the lower greensand and chalk of Kent and Sussex, thus offering the most important addition to the flora of that period since the publication of the compendious memoir of Dr. Fitton. The other memoir is upon certain small dark brown concretions from the lower greensand of Maidstone, and to

* Proceedings, vol. iii. p. 126.

† See observations on the Neocomian not being an equivalent of the Wealden, p. 67. I may here also state, that Mr. Robertson of Elgin has discovered some of the fresh water shells of the Wealden, intercalated in the oolitic strata of Brora. His memoir will soon be read.

which Dr. Mantell has given the name of Molluskite, in consequence of their being supposed to be the carbonized remains of the soft parts of Mollusca. This communication is the result of the researches of Mr. W. H. Bensted of Maidstone, who collected slabs full of these concretions, previously supposed to be of coprolitic origin, but he suggested that they might be the soft portions of testaceous Mollusca. When free, and where the peculiar substance had been formed in considerable quantity and in a pure state, it was inferred by Dr. Mantell that the soft parts had floated away from the shell after the death of the animals, as often occurs at present among living testacea. Chemical examination by the Rev. J. B. Reade and Mr. Rigg detected animal carbon in the substance of some of these bodies.

Tertiary Period.

The session has not added much to our knowledge of British Tertiary deposits. Mr. Trimmer, well known to us by his researches in detrital phænomena, has lately expressed his opinion that the peculiar eroded surface of the chalk, in which pipes filled with sand or gravel are of frequent occurrence, was produced by the action of the sea during a period which preceded the deposit of the London clay. There can be no objection to this view being applied to all those corroded surfaces of the chalk, which are surmounted by the Eocene deposits of plastic clay and sand and London clay, including, I would add from the recent observations of Count Keyserling and myself, the junction of the chalk and Lower Tertiary in Alum Bay. It would, however, be manifestly wrong to suppose, that such a corrosion of the surface of the chalk had not also been effected at other and subsequent periods; and as proofs of a still more recent corrosion, the observer has only to examine the shore and cliffs near Brighton, and see how similar cavities have been filled up by a breccia, in which the bones of elephants are imbedded.

Some remarkable concretions in the Tertiary beds of the Isle of Man (where the newer marine Pliocene strata were first described by Professor E. Forbes, and shown by him to occupy perhaps a larger area than in any one locality of the British Isles), have elicited from Mr. H. Strickland the suggestion, that they were caused by currents of water, or by the action of wind during ebb-tide.

Among the terrestrial phænomena which have recently excited notice, is the discovery by Dr. Riley of a bone-cavern in the Moun-

tain Limestone of Durdham Down near Bristol, the opening of which has been conducted by Mr. Stutchbury, who has described its contents. Distinguishing, as Dr. Buckland had formerly done, the cavities formed by fissures in the rock, into which bones had been washed with detritus of rocks and soil, or into which whole animals had fallen, from caverns inhabited by extinct species of canine animals, Mr. Stutchbury shows, that the facts observed in this case entirely favour the latter hypothesis, the bones (among which those of the hyæna vastly preponderate) being fractured into small bits without the admixture of any rolled or far-transported detritus. The most novel point connected with this cavern is, that several of the hardest bones and teeth have been split across, and their parts relatively moved, as if the detrital mass had been affected by faults posterior to its original deposit, which movements may, Mr. Stutchbury supposes, have been connected with the operations which closed the orifice of the aperture *.

Geological Dynamics.—Detrital Phænomena.—Raised Beaches and Shingle Terraces.—Marks of Ancient Levels of the Sea.—In previous years Mr. Hopkins led the way in applying mathematical and mechanical knowledge to geology, and in a memoir which will, I trust, soon appear in our Transactions, he shewed satisfactorily, that the transverse fissures through the ranges which bound elliptical areas, are the necessary mechanical effects of the upheaval of such districts. He now lays before us a memoir on the elevation and denudation of the lake districts of Cumberland and Westmoreland, in which, going further, he encounters some of the most difficult problems in geological dynamics. The first of these is to reconstruct exactly the former conditions of this district, and certain data being assumed, to deduce a series of geological events, the occurrence of which would explain the present position of the different rocks, as so many fragments of a former whole, which has been broken up at two distinct periods of eruptive agency. If all the premises which Mr. Hopkins assumes be granted, there can be little doubt, that with his profound mathematical and physical knowledge, his deductions will be accurate; but I confess that two of his postulates, viz. a perfectly smoothed down surface of the older rocks anterior to the deposition of the Mountain Limestone, and the former

* A similar case occurred in the gravel beds of Darmstadt, where the Dinotherium was found.

persistence of a continuous mantle of the latter rock over the transition, metamorphic and plutonic rocks, seem to me to be very difficult to understand.

On referring to the opinions which Professor Sedgwick has published on the structure of the Lake Country*, I perceive, that whilst he agrees with Mr. Hopkins respecting the comparatively modern origin of the existing lakes and valleys, he does not believe with him that the whole of the valleys were formed posterior to the Mountain Limestone. On the contrary, he thinks that there are rudiments of diverging valleys of an older period. Professor Sedgwick must also I presume reject the hypothesis of the Mountain Limestone having at any period been deposited as a continuous calcareous sheet upon the older rocks, for he has expressed his belief that the limestone was accumulated as an external fringe like a vast coral reef around a cluster of more ancient rocks.

But whatever may be their differences on these points, I have reason to think that Professor Sedgwick entirely concurs with Mr. Hopkins, in the necessity of calling into play enormous aqueous currents (which followed elevations) to account for much of the coarse drift which has been poured off upon the flanks of this mountain chain. Unwilling to call in the assistance of icebergs, and opposing the hypothesis of a depression of temperature, Mr. Hopkins shows, that the propelling forces of water alone are fully adequate to produce the transport of all the blocks and gravel around the Cumbrian chain, and to spread them out in the great masses of drift which encumber the adjacent northern centres, accounting for the existence of diverging currents by a number of paroxysmal elevations. Assuming moderate upheavals of certain areas of land, to a height of 50 feet each, from beneath an ocean having a depth of 300 and 400 feet only, he informs us that a number of great divergent waves would be the consequence.

In describing the motion of such masses of water, he invokes the aid of those waves of "translation" whose properties have been reduced to laws by the ingenious and valuable researches of Mr. Scott Russell, and who, giving us measures of their relative velocity and power, has brought forward exact proofs of the transference by them of solid bodies immersed in water. Such waves have in fact been generated by the experiments of Mr. Scott Russell, exactly in the

* Letters to Wordsworth in the New Guide to the Lakes.

same way as Mr. Hopkins supposes waves to have originated on the great geological scale. These experiments prove, that a sudden elevation of a solid mass from beneath the water, causes a corresponding elevation of the surface of the fluid, which infallibly produces a wave of translation of the first order. Now this wave is termed one of *translation*, because it is found not to rise and fall like common waves, but wholly to rise and maintain itself above the level of the water. Arguing that this wave is propagated with a velocity which varies with the square root of the depth of the ocean, Mr. Russell determines the velocity of wave transmission; but what is of most importance to the geologist is, that the old idea of the agitation and power of waves extending a little way down only in the sea, is found to be not true as touching waves of translation; for Mr. Scott Russell has ascertained that when they are in action, the motion of the particles of the water is *nearly as great at the bottom as at the top*. He further shows, that the body moved at the bottom, is not rolled backwards and forwards as by a common surface-wave, but has a continuous forward motion during the whole transit of the wave's length. A complete transposition does therefore result from the wave-transit; and the wave of translation, says Mr. Scott Russell, may be regarded as a mechanical agent for the transmission of power as complete and perfect, as the lever or the inclined plane.

Arguing from these remarkable data of Mr. Scott Russell, and applying them to our geological phænomena, Mr. Hopkins states, that currents of twenty-five and thirty miles an hour may be easily accounted for, if repetitions of elevations of from 160 to 200 feet be granted; and with motive powers producing a repetition of such waves, our author has no difficulty in transporting to great distances, masses of rock of larger dimensions than any boulders in the North of England.

In bringing his mathematical and mechanical knowledge to bear on this difficult question, Mr. Hopkins has rendered essential service to geologists, well convinced, as they must be, that no one cause could have been adequate to the formation of all the varieties of superficial detritus. He has in short arrived at numerical results, acquainting us with the exact influence of the moving power, under certain conditions*.

* See Proc. Geol. Soc. vol. iii. p. 766. See also a hypothesis by the present Master of Trinity Coll. Cambridge, on this subject, Silurian System, p. 538.

Admitting with Mr. Hopkins, that nearly all the great boulders at a distance from the mountains from whence they were derived, were accumulated upon the bottom of the sea, which bottom was subsequently elevated, I regret, that whilst he allows the possibility of floating ice having played a part in some cases in the transport of large blocks, he should doubt its agency in the country under consideration; for the North of England is full of examples of far-borne detritus, the position of which seems to me inexplicable by calling in the power of water *alone*. Many practical geologists must, I think, admit, that in the desiccation of the former bed of the ocean, and in its conversion into our present lands, the submarine outline of hill and dale has been, to a great extent, preserved; and if this be granted, no waves of translation nor any force of water can have hurled blocks across high ridges and deep valleys which are *transverse* to the direction which the erratics have taken, and of such relations England offers numerous examples. To a remarkable instance of this transport in our central counties I formerly adverted, contending that without the agency of floating icebergs the phænomenon seemed inexplicable*, and I now direct your notice to an excellent example of this nature, which was communicated by Mr. Clay at the last meeting of the British Association, who shows that in the narrow valley of the Calder excavated in the carboniferous strata, there is a group of boulders of granite and other crystalline rocks, of which there are no traces in any part of the adjacent country. As these blocks are separated from the Cumbrian chain by the lofty region of Lancashire, and numerous deep, transversal or east and west valleys, it is quite manifest that no force of water could have hurled them to this position, their detached nature seeming singularly to favour the hypothesis, that they were carried thither by a large mass of floating ice, which, on melting, left them as an isolated group in this remote valley, then probably a bay or frith of an arctic sea.

Glacial Theories.—The glacial theory, as at first propounded, has now, I apprehend, very few supporters, but to any such I recommend the perusal of the theoretical investigation of Mr. Hopkins, 'On the Motion of Glaciers;' for he has shown, by clear mathematical analysis, that the locomotion of such bodies over large and

* Silurian System, p. 535 *et seq.*

flat continents is a theory founded in mechanical error, and involving conclusions irreconcilable with the deductions of collateral branches of physical science.

Having occupied so much of your time last year with observations on the theories respecting the action of ice under both terrestrial and marine conditions, and having then so fully expressed my opinions on the impracticability of explaining the transport of erratic blocks to great distances, except by the medium of *floating* ice, I shall no longer enter into the list of disputants upon a question which must be long studied, and viewed under various aspects, before good and firm conclusions can be separated from those which are loose and dangerous. I must, therefore, content myself with referring you to the additional communications of M. Agassiz to the Institute of France, and to the writings of Professor James Forbes*. The new views of the subject which are introduced by so profound a mathematician as Mr. Forbes, lie rather beyond the compass of the practical geologist, and lead into the domain of pure physics. As geologists, however, you must not omit to consult that excellent work on the Glaciers of the Alps, by our eminent foreign associate M. Charpentier, of the existence of which I very much regret to have been ignorant when I last addressed you; for to whatever extent we may be led to agree with or dissent from his theories, it is quite manifest that they are founded on patient and very long-continued observation of facts. Nor will you pass over the ingenious views of M. Hugi, long known as an Alpine geologist; and you will sift the value of the evidences on which he grounds his rejection of the views of Professor Agassiz. This subject is now, indeed, so extended, that without revisiting the Alps or some active centre of glacial action, it would be presumptuous to advance any further opinions of my own.

Ready as I have always been to admit the transport of blocks in ice from any former seat of congelation, and particularly in tracts where marine shells of arctic characters are associated with the surrounding drift, I am here, however, bound in candour to state, that in my desire to see established as a fundamental point of reasoning, "the submarine condition of by far the largest parts of the surface of Northern Europe when erratics were distributed," I have been carried too far in my Discourse of last year, in the endeavour

* Edinburgh Phil. Journal, 1842.

to limit the number of centres from which icebergs may have been detached. Whilst, therefore, I cannot bring my mind to advocate that extent of glacial action in which my friend Dr. Buckland believes, and have failed, in a recent excursion, to observe any proofs of the existence of "moraines" on the flanks of Snowdon, I allow that, looking to the sea-shells which lie around it at different altitudes, the summits of Snowdon may, like those of Spitzbergen, have constituted icy peaks in the midst of an ocean, others being at the same time in existence in the mountains of Cumberland. This is, I am persuaded, the full extent to which we can admit the application of the glacial theory in England, and it therefore appears to me to be futile to look for marks of terrestrial glaciers upon the surface of the rocks of Cornwall or on our southern and eastern counties, the coasts of which exhibit beds of marine gravel and shells at different altitudes upon the cliffs. This observation leads us away from Alpine theories little suited to our island, and carries our thoughts to other superficial phænomena, some of which we can much more satisfactorily explain by means of our own insular evidences*.

Raised Beaches, and proofs of ancient Levels of the Sea.—In a recent report to the French Institute, our foreign Associate, M. Elie de Beaumont, has given the substance of a most important memoir by M. Bravais, 'On the Lines of Ancient Sea-level in Finmark.' Informing us that this work proceeds from the pen of a naval officer attached to one of those numerous scientific enterprises conducted at the public cost, which do so much honour to the French government, M. de Beaumont embodies the labours of M. Bravais in a lucid analysis of many of the facts relating to the same subject, which have been accumulated in Norway, Sweden, and the British Isles.

Proofs of the elevation of the coasts of Norway have been brought before geologists by Von Buch, Brongniart and Keilhau, and have recently been extended by M. Eugene Robert to Spitzbergen. Mr. Lyell has made the British public familiar with the great oscillations which the land of Sweden has undergone since the existence of the present marine fauna; (for Scania has been depressed beneath the Baltic, whilst other parts of Sweden have been raised) and I may be permitted to add, that the extent to which elevations have

* See letters addressed to Sir Charles Lemon, Bart. M.P., published in his last Discourse as President of the Royal Geological Society of Cornwall.

affected the north-eastern corner of Europe has been recently pointed out in Russia by my companions and myself.

In the prelude to the report on the part which M. Bravais has performed in these labours, we are put in possession of the results of the valuable researches of Professor Keilhau, who, prior to the French expedition, had ascertained the levels of different accumulations, all supposed to be marine, from the sea-shores to altitudes of above 600 feet in the interior of Norway.

The greater number of geologists have for some time believed, that these phænomena could alone be satisfactorily explained by upheaval of the land, and M. Bravais has, by a new method of proof, arrived at the same conclusion.

Passing about a year in the environs of Hammerfert, he observed that terraces of gravel in some spots, and marks of erosion on the face of the cliffs at others, indicated at least two ancient lines of sea-level, which extended from the coast far into the interior along the sides of the sea-loch of Alten fiord. Availing himself of the water-mark left by the line of sea-weeds (*Fucus vesiculosus*), and estimating from that horizon an approximate mean level of the tide, he instituted a series of exact measurements of the altitude of both the lower and upper sea beaches, or ancient water-marks upon the rocks, at six different stations between the mouth of the fiord and its southern extremity, a distance of ten to eighteen leagues, and he arrived at the striking result, that the two terraces of Alten fiord, which at first sight, or seen only to a limited extent, seemed to be horizontal and parallel, are, when measured rigorously, found to rise from the levels of 46 and 92 feet (English) above the sea near the mouth of the firth to the heights of 90 feet and 22 feet at its further or inland extremity! In referring you to the Memoir for the ingenious and accurate methods employed by the author to obtain these results, and of which M. de Beaumont has given a very clear account, I will here simply direct your attention to some of the chief geological considerations with which they are involved.

As these lines of deposit rise towards the interior, so as to mark that they coincide nearly with the chief axis of elevation of the Norwegian chain, and as there is a want of parallelism in the two beaches, the relative altitudes of which vary much in short distances, so is it obviously impossible to account for the phænomena by any

former condition of the tides; and the hypothesis of salt water lakes is, from the same causes, equally inadmissible.

Submarine currents dependent upon violent elevation of the chain will, the author contends, no better explain the phænomena, because the torrential debacles which would have accompanied such movements would have left confusedly assembled drifts, and not regularly arranged terraces. It therefore seems fair to admit that these are truly ancient sea-beaches. The measurements of M. Bravais show, in fact, that in proceeding from the coast into the interior these beds not only rise to higher levels, but that their elevation has been irregular, viz. that whilst the sea-ward inclination of the older or higher of the two terraces, taken from a station at the middle of the fiord, is very moderate, the rise of the same beds from that central point to the southern extremity of the fiord is at a greater angle, and therefore, that there has not only been a much more intense movement of elevation over one portion of this area than another, but that this notable change of dip indicates the greatest movements at the two extremities, the centre varying slightly from the horizontal. Now from these facts (independent of all the geological evidence) it is argued, as before observed, that no change of level of the sea will account for such an outline.

I will pass over those parts of the report which are connected with pure physics, not only on account of my own incompetency to do justice to them, but because I would suggest, that however certain geological phænomena may be eventually proved to be connected with the question of the density of the earth, it is obvious that unequal simultaneous elevations and depressions over so small an area as Scandinavia can scarcely be due to such a cause. After ably treating this subject, and showing that great terrestrial movements only can be admitted as explanatory of the facts observed, M. de Beaumont refers to the works of British geologists, and suggests, as indeed Mr. Phillips has done*, that the parallel roads of Glen Roy may, by accurate measurement, be proved not to be parallel; and he then goes on to show, that the lines of ancient sea-level of comparatively modern periods, have undergone broad undulations or great ascending and descending movements over extensive areas.

Let us see how these views are strictly applicable to our own country. The occurrence of ancient beaches containing marine

* See Penny Cyclopædia, *Parallel roads.*

shells of existing species at different levels above the sea has long been observed by geologists in the British Isles. Terraces of gravel have also been noted at various altitudes. In some instances they have been referred to the formation of lakes, but in others they have been compared to sea shingle; in many cases also they have been merged with diluvial deposits, and latterly an endeavour has been made to explain some of them by the action of glaciers which are supposed to have barred up former lakes. It may be that we should not endeavour to refer the whole of these phænomena to one common origin; though most persons must admit that the mass of recent evidence proves the greater number of the superficial deposits, to which allusion is now made, to have been formed beneath the sea. Wherever, indeed, these accumulations are found to contain marine shells so imbedded in the sand or gravel as to resemble sea bottoms, and no doubt can remain of their origin, the only question is, why do we find these shells at such different altitudes? why are the same marine remains (appealing to British examples) placed at the height of upwards of 1600 feet in North Wales, and a few feet only above the sea in Devonshire and Cornwall, and at heights varying from 200 to 400 in the central counties? Most geologists have been satisfied to reply (and I am myself of the number), that in these evidences they had distinct proofs, not that the sea had stood at an indefinite number of levels, thereby making a most broken and irregular outline *within the same period* (a supposition apparently absurd), but that the bottom of the sea had undergone irregular oscillations, some points having been raised to much greater heights than others. The examination of the mountains of North Wales and the adjacent plains of Shropshire, for example, could lead to no other inference; there being in tracts absolutely contiguous, a difference of not less than 1000 feet between the level at which the same species of marine shells are now lying: and as no other portion of England or South Wales offers a trace of testacea at the higher of these altitudes, it is demonstrable, that when the sea deposited the shells in Moel Tryfane it did not stand at that height above the whole of England, but that the local appearances resulted simply from unequal elevation of the sea's bottom.

All the analogous phænomena in the British Isles seem to lead to the same conclusion. Whilst the modern marine alluvia of the central counties are found to rise towards Snowdon as a great centre of

elevation, the banks of gravel with similar shells ascend from the coasts of Lancashire towards the Penine chain in the interior. Again, in the south-west of England, the most distinct sea-beaches yet noticed, were ascertained to rise very perceptibly from a low level on the south coast of Devon and Cornwall, to heights of 120 feet above the sea in North Devon, where the elevation is more intense. The valley of the Severn afforded similar proofs; the beds of gravel with sea-shells, between Worcester and Gloucester, near its estuary, are slightly elevated above the sea, but in ascending to its source, the same gravel and shells occur at altitudes of 500 to 600 feet, until finally they are seen in the lofty cliffs of Moel Tryfane, before alluded to.

Whilst such may be justly received as absolute proofs (quite as clear as those of M. Bravais) of more intense elevation at some points than at others, the submarine forests along our coasts have been supposed to offer proofs of subsidence. These evidences, however, are not of the same satisfactory nature as those of elevation, for it may in some instances be contended, that the forests in question grew upon low deltas, and have been overwhelmed by irruptions of the sea, which broke down certain banks or natural barriers, that at one period protected them from inundation. But granting these submarine forests on the east coast of England to be really as good proofs of a depression of the land as any which exist on the shores of Scania, where a great subsidence has been established, it must also be borne in mind, that the rocky western coast of our island offers equal signs of depression, since Cornwall and Pembrokeshire, and even Cardigan, so near to the point of intense elevation, Snowdon, have each their submerged forests as well as Lincolnshire. Examined, then, as a whole, England offers many evidences which to me seem conclusive, that within a very recent period, the land has undergone great and unequal movements, both of elevation and depression, in relation to the level of the sea. Scotland and Ireland present like phænomena. In the latter country modern marine shells have been found in many localities at various altitudes. Scotland, so rich in superficial accumulations, also offers near her shores many testimonies of former sea-bottoms laden with numerous shells, but hitherto these remains have only been found at comparatively low altitudes. Another

class of detritus, in which, in common with England, she is rich, consists of extensive irregular accumulations of clay, boulders and gravel, usually called "till," and which may be compared with the drift of the tract extending from Bedfordshire and the eastern side of Huntingdonshire, to the coasts of Norfolk, Suffolk and Essex. A third class is composed of gravel and sand, often arranged in terraces, which in some cases occur at different levels, following the sinuosities of the bays and headlands of the seacoast; in others ramifying into the interior, along the sides of deep cavities occupied by freshwater lakes.

The well-known "parallel roads" of Lochaber offer the most striking example of terraces at different levels above a series of existing lakes, and their explanation has been long the subject of controversy. For many years it was the favourite hypothesis, based, however, upon the supposition of their *perfect parallelism*, that these lines of shingle were the shore lines of the lakes when they stood at higher levels, from which they have been successively let off by the breaking down or wearing away of their barriers. Though supported by several good observers, this view has always presented great difficulties as to the demand upon our belief in the wearing away and destruction of enormous barriers. Very recently, indeed, the expounders of a terrestrial glacial theory have at once obviated all difficulty, by constructing in their imagination enormous walls of ice 2000 feet high, by which such lakes were formerly supported, and by the sudden melting of which they have been let off.

Unable to screw my courage up to the belief in this glacial explanation, I will not now repeat the many objections which must be raised against it, but will simply join those who prefer to invoke the more rational, and, as it appears to me, perfectly satisfactory hypothesis, that all these terraces of gravel (including those of the parallel roads) are nothing more than ancient lines of beach, which are so many marks of the successive rise of the land. This view is, that, as you all know, which was so ably sustained by Mr. C. Darwin, who, in pointing out their analogy to raised beaches in other countries, has also shown, that as similar materials occur in the great chasm of the Caledonian Canal at still greater altitude (900 feet above the sea), it was impossible to refer them to any other cause than submarine elevation. I have too long entertained the

same opinion respecting most of the great gravel accumulation of our isles, to doubt that this is the true explanation. I would add, however, that the southern shores of the Murray Frith, which are of course open to the wide ocean, offer to my eye still more convincing proofs of the accuracy of this view, than the patches of gravel along the Caledonian Canal. The terraces of gravel, sand and boulders which there occur at different levels, may, in fact, be traced from the slopes of the mountains of Morayshire and Elgin, to those heaps which lie in the great gorge of the centre of the Highlands; and therefore I maintain, that all these accumulations must have been once connected, and were all originally formed under the sea.

No one who has read M. de Beaumont's report on the memoir of M. Bravais, can fail to be struck with the strong, nay even direct analogy which the gravel and shingle beds of the marine bays and freshwater lochs of the Highlands of Scotland bear to the terraces of the Norwegian fiords; and as the latter author has now by patient observation brought the phænomena observed among the latter under the direct control of geometrical admeasurement, and has shown that such lines, when correctly examined, are neither horizontal nor parallel, so is it my duty, believing that many of the Scottish gravel terraces have been produced by similar agency, to incite my brother geologists to apply the rigorous method of examination of M. Bravais, and thus to render this branch of our inquiries more exact. I entertain, indeed, the most sanguine hope, that before another anniversary passes over, the Scottish phænomena will be tested in a similar manner with those of Norway; and, that as the beds of marine shells in England and parts of Scotland and Ireland so clearly bespeak great irregularities of movement in the land, so we shall be equally able to show that in the Highlands, lines of elevation acting from different centres and with different degrees of intensity, have raised former sea-bottoms to the different levels at which we now find them, whether along shores or in the deep lateral depressions by which Scotland is so fissured. Let the memoir of M. Bravais therefore, with the admirable commentary of M. Elie de Beaumont, be the stimulus to those who enter upon this inquiry, which should not be limited to the parallel roads of Glen Roy, but extended to the Western Islands and shores of the lochs of Western Ross, among which I have a recollection of numerous shingle terraces, including that

so well described by Captain Vetch*; and eastwards, to the great accumulations adverted to on the southern shores of the Moray Frith, which in their turn should be connected with the elevated shelly beaches of Banffshire, first pointed out by Mr. Prestwich†.

In quitting the consideration of this very interesting topic, I cannot however occupy this Chair without saying, that albeit British geologists have not yet employed the rigorous test applied by M. Bravais, there is no department of our science on which their observations have thrown more light than that which embraces the phænomena of ancient sea-beaches. Reasoning backwards from existing causes and the facts of yesterday, Mr. Lyell has, by a well-digested set of observations, led us to contemplate the very period when the ocean was beating against our inland escarpments of chalk, and when our valleys and those of the opposite coasts of France may have been fiords like those of Norway‡.

I also know that my friend Mr. Lonsdale has long entertained similar views, derived from his intimate acquaintance with the escarpment of the oolitic strata; along some of which he has observed as perfect lines of dunes as those upon the sea-coast of France, whilst in others he has been struck with their resemblance to many great dislocations of marine undercliffs, whereby masses of the inferior oolite have been pitched into inclined positions at the bottom of the adjacent valleys; and as I know that this subject is one which now occupies his attention, I have strong hopes that by his present residence on the coast of Devonshire, he will be enabled to add materially to the exact conclusions which have been already drawn in this class of researches.

Russia and the Ural Mountains.

Having occupied your attention during the past session with memoirs on the Geological Structure of so large a portion of the earth as the Russian empire, I must make a few allusions to a subject which has to a great extent engrossed my thoughts and those of my coadjutors, M. E. de Verneuil and Count A. Keyserling. Employed as we

* Geol. Trans. vol. i. p. 416.

† M. de Beaumont makes full allusion to the British cases.

‡ Elements of Geology, vol. ii. pp. 3—8.

are in preparing a work explanatory of our views, in which we hope to do justice to all previous inquirers*, and to the Imperial Administration of Mines which supported us, I will not on this occasion venture to occupy more time than will be sufficient to touch upon some of the most striking geological features of that empire, which either sustain or enlarge our views of classification and comparison.

Silurian Rocks.—The Silurian, Devonian and Carboniferous deposits of Russia, are each characterized by distinct organic remains; and these rock systems are very clearly separated from each other over enormous spaces. Occupying (including the Baltic islands) a tract as large as the principality of Wales, the Silurian rocks, like those of Norway and Sweden, are unequivocally the oldest fossiliferous strata, since they are seen to repose upon the primary crystalline masses of Finland and Lapland. Little elevated above the Baltic Sea and the rivers of the northern watershed of Russia, these Silurian rocks constitute low plateaus only of limestone, clay and sandstone, often incoherent, and on the whole of very small thickness; thus exhibiting the most obvious contrast to their mountainous and frequently sub-crystalline equivalents in Western Europe and the British Isles. In their small vertical dimensions they present to us, indeed, a very instructive lesson, for in passing from Norway, Sweden and Gothland into Russia, the distinguishing strata thin out, and losing their divisionary lithological characters, part also with many of their characteristic shells. "When followed from one region to another, deposits of all ages exhibit like contractions and expansions, dependent on the forms of the ancient bays, the nature of the springs and currents, and the depth of the seas in which they were accumulated†."

Devonian Rocks.—If the horizontal range of the Silurian rocks of Russia be considered large as respects our terms of comparison, what will my associates say to the expanse over which the Devonian or next ascending group is spread, when I tell them that it is much larger

* During its preparation, our general map of the Russian empire has been much improved in its north-eastern extremity, the country beyond Archangel which we did not visit, in consequence of the observations of the distinguished botanist M. Ruprecht.

† Geological Researches in Russia (in the press) by Roderick Impey Murchison, E. de Verneuil, and Count A. von Keyserling, assisted by Lieut. Koksharof, p. 40.

than the whole of the British Isles? Reposing upon the low Silurian plateaus, this widely ranging deposit rises to heights of from 500 to 900 feet above the sea; and it is very remarkable by being charged in many localities with ichthyolites, several species of which, hitherto considered peculiar to the Scottish Old Red Sandstone, are found associated with Mollusks, perfectly similar as a group, and often specifically the same, as those of the limestones of South Devon, the Boulonnais and the Eifel. The discovery of the intermixture of Scottish Old Red Sandstone fishes and true Devonian shells in the same strata, was, you may believe, one of the most gratifying results of the recent explorations in Russia, as being confirmatory of the views of Professor Sedgwick, Mr. Lonsdale and myself respecting the divisions and equivalents of that member of the Palæozoic Rocks. In some parts of Russia, the Devonian rocks are red sandstones and marls; but in an extensive central tract, where they rise into a dome which separates the northern from the southern basin of the empire, they are composed of yellow sandy marls and limestones, which lithologically might be mistaken for the magnesian limestone beds of our northern counties:—so inapplicable are mineralogical terms as marks of geological epochs.

In the vastness of their undisturbed and nearly horizontal extent, these strata afford us most instructive proofs of the intimate connection between the stony condition of the rocks and the imbedded fossils; for, when the calcareous matter is present, various mollusks are associated with some fishes, whilst in those tracts where the limestones disappear and the beds have the characters of the Old Red Sandstone of Scotland, fishes only can be detected: thus presenting a remarkable analogy between the distribution of this very ancient fauna and that of existing nature; the present great receptacles of fishes being deep sandy bottoms, whilst shelly creatures congregate towards the shores where calcareous springs attract them. I shall elsewhere allude to the fishes of this deposit when speaking of the researches of Professor Agassiz.

Carboniferous Rocks.—The Carboniferous deposits, which succeed, cover an area as broad as that of the Devonian or Old Red rocks; and they are throughout clearly distinguished by a decidedly distinct type of animal life, presenting in some families an extraordinary number of species absolutely undistinguishable from those of

our own country published in the works of Sowerby and Phillips. This system is eminently calcareous, and exhibits a vast marine succession, in which the fossils of the Mountain Limestone prevail, whilst in no part of the empire is there a trace of the overlying deposits, with which we are familiar under the term of "coal-measures." Coal, however, does occur at intervals, both underlying the carboniferous limestone, as in Berwickshire, and alternating with its central and upper members, as in Northumberland, and the carboniferous valleys of our lake country.

Of the latter, the extensive tracts in the south of Russia, occupying from 10,000 to 11,000 square miles, and usually known as the country of the Donetz, offer a very striking illustration; containing in one district as many as seven good seams of coal, subordinate to sandstone, shales and limestones, very analogous to those rocks which abound in the western dales of Yorkshire. These strata, based upon the crystalline rocks of the southern steppes, constitute a greatly disturbed region, and, owing to numberless convolutions, present the most remarkable contrast to the horizontal deposits of Central and Northern Russia. It is therefore difficult to observe the order of succession; but, owing to our previous acquaintance with the types in their normal condition, we were enabled to trace the sequence, from conglomerates and sandstones at the base of the carboniferous limestone, up to the equivalents of the Magnesian Limestone or Zechstein.

Whilst thus briefly alluding to this tract, I must pass, for a time, from my own labours, and those of my friends, of the value of which you must judge when our work is completed, in order to mention the recent appearance of the fourth volume of the splendid work of M. Anatole Demidoff, 'Voyage dans la Russie Méridionale,' which is entirely devoted to the description of the carboniferous region of the Donetz. M. Le Play, an eminent French engineer, happily selected by M. Demidoff to ascertain the true mineral wealth of the tract, and to describe its physical and geological structure, has produced a work so replete with well-digested details, collected, not only from observations of the natural features of the region and the mines which have already been commenced in it, but also by numerous borings carried on by himself or his assistants during a period of three years, that the Imperial Government will doubtless

feel grateful to the accomplished patron who has so liberally fostered these inquiries.

In a large geological map, in which the demarcations of the carboniferous and crystalline rocks, and also of the overlying secondary and tertiary deposits are given, M. Le Play has grouped under darker colours such parts of the tract as are known to be productive of coal, to distinguish them from those in which the mineral has not yet been discovered. This method, doubtlessly, carries with it a certain amount of information, but is deficient in stratigraphical meaning, for some of the beds so marked are higher than others; in some the coal is interlaced with limestone, and in others it is almost entirely subordinate to sandstone and shale; in one tract anthracite exclusively prevails, in another bituminous coal. By reference, however, to the explanation, and to a series of tables, this defect is obviated. These tables are, in fact, perfect models for the practical mining engineer; they give at one view the direction, inclination, thickness and quality of the coals at each locality, also the characters of the associated strata, as well as the state of the works, and their produce at each mine or trial-spot. To these is added another set of tables, in which the chemical analysis of the coals from forty-three different places is given by M. Malivaud, another agent of M. Demidoff.

Into such details, valuable as they are, it was not our province to enter, and I will now, therefore, merely offer a few remarks explanatory of those points in which the geological conclusions of my friends and self either agree or are at variance with those of M. Le Play.

Certain fossils which he had brought to France, and which we inspected before our journeys to Russia (1840), first led us to believe, that these coal beds are subordinate to the carboniferous limestone. Of this, indeed, there could be no doubt, for the species were, to a great extent, the very same as those with which we were familiar in rocks of that age in western Europe. On interrogating M. Le Play, however, we could not ascertain that he had arrived at any defined idea of a succession of strata, derived either from the stratigraphical order of mineral masses, or from their imbedded organic remains. In fact, he then distinctly acquainted us with what has now appeared in his work, that, owing to the disturbed and convoluted condition of the strata, the want of persist-

ency of mineral characters, and the apparent existence of similar species of shells throughout the series, it was impracticable to assign a base line to the deposits, or to trace their uppermost limits, still less a passage into any superior formations.

Now, as we have ventured to effect these objects, with what success we must leave others to decide, I will here briefly state why I conceive M. Le Play did not arrive at similar results; although he had in his own hands some means of proof, which, through the short time at our disposal, we never obtained.

No geologist, however practised, can, I venture to say, explain the structure of any complicated part of a distant country, unless he has made himself master of the clear succession of its normal formations. Long as I have been occupied in the study of the Palæozoic rocks, I am confident that, had my friends and myself been thrown suddenly into the chain of the Donetz, and had been desired at once to unravel its complexity, we should have reached no other geological result than that to which M. Le Play has attained, viz. of stating that the coal-seams are, as a whole, subordinate to the carboniferous or mountain limestone. We had, however, by two years of extensive comparative researches, obtained an intimate acquaintance, not only with the older Palæozoic rocks of Russia generally, but, in reference to the carboniferous system, had convinced ourselves, that, throughout the enormous area over which we had traced it, the upper or coal group of western Europe was absent; and that the calcareous or lower group, occupying the whole carboniferous horizon, was divisible into three stages, by help of certain fossils characteristic of each. Again, we had ascertained, by numerous sections on both flanks of the Ural Mountains, that, in becoming part of a mountain mass, this system, so uniform and so peculiar over a space as large as an ordinary European kingdom, put on many of the features which are so well known to those who have studied the carboniferous limestone only in the western parts of Europe.

We further learnt, that, in the absence of any deposits to represent our great coal-fields, the carboniferous system was succeeded, in ascending order, by a vast series of red and cupriferous deposits to which we have assigned the name of Permian. It will not, therefore, be arrogant on our part to say, that we entered upon

the examination of the territory of the Donetz, in the possession of elements of comparison which no previous travellers had acquired.

Knowing, from the maps and instructions furnished to us by the Imperial Administration of Mines*, that the major axis of this tract and the main direction of the strata trend from west-north-west to east-south-east, we resolved, after terminating our researches in Southern Russia, to examine the chain of the Donetz in parallel lines transverse to its general strike; and, by carrying out this scheme, we arrived at the conclusion, that the oldest member of the series occupies its southern frontier, and that, after a multitude of flexures, the central strata dip under a limestone charged with Fusulinæ, fossils which we had invariably found in the uppermost bands of limestone; the whole group being surmounted in the valley of Bachmuth by the equivalents of the Permian system. One striking deficiency, however, attached to our reconnaissance, and fortunately it has been supplied by M. Le Play himself. Those members of the Society who heard our memoirs read, will recollect the importance we attach to the presence of the large *Productus giganteus*, as uniformly characterizing (over vast regions in Russia) the lowest beds of the carboniferous limestone: and, as we now learn from M. Le Play, that this fossil, of which he collected many individuals, occurs in the southern part of the region, our idea is thus completely confirmed of an ascending section from south to north.

In fact, the examination of the carboniferous region of the Donetz is one of the best examples that can be adduced, of the paramount importance to the practical miner of the close study of organic remains, in reference to the normal position of the strata; for, throughout deep sections in the northern part of the same territory, there is not a trace of this great Productus, whilst all the fossils of the middle and upper strata are present. Any one, therefore, who had felt as confident as we do, that this remarkable fossil was as clear an indication of a lower band as the *Spirifer Mosquensis* and Fusulinæ are of an upper, could not have doubted of the general relations and order of the strata in the chain of the Donetz.

* The instructions of General Tcheffkine, the works of Captain Ivanitzki, and a map by Colonel Olivieri. See Journal des Mines, &c.

Agreeing in the correctness of the general parallel which M. Le Play has drawn between the deposits of the Donetz and the carboniferous limestones of Great Britain, Belgium and France, I do not believe that beyond this point his comparisons can be sustained. The coal fields, for example, of the Low Countries and of Düsseldorf, with which I am well acquainted, do not offer, as he supposes, an analogy to those of the Donetz; for in the former, coal-seams are in no instance interstratified with the Mountain Limestone series of English geologists, but are invariably superposed to it. Again, in the Prussian and Belgian provinces, the mountain limestone with sands and shale but void of coal, reposes on a fine succession of Devonian and Silurian rocks, loaded with typical fossils; whilst the group of the Donetz, exclusively carboniferous to its base, rests at once either on very ancient crystalline rocks, or upon porphyries and other eruptive masses, to the agency of which is to be attributed the extraordinary contortions into which the strata have been thrown. The true analogy, therefore, of the coal of the Donetz, considered in reference to other deposits of the same age, is to be found in the north-western English districts of mountain limestone, in which several workable seams occur; though in this comparison it must be stated, that the Russian beds contain much more coal than the British strata. But even if we admit that, to some extent, there is a similarity in the carboniferous rocks of South Russia and the Low Countries, in their being both flanked by cretaceous deposits, we must also not omit to recognise a great discrepancy, through the presence in the one case of overlying strata of the age of the Zechstein, and in the other by the total absence of that deposit.

To considerations of theoretical importance concerning the changes which the surface of Southern Russia may have undergone, and which are ably put forth by M. Le Play, I will not at present advert; reserving my views on these points for the concluding chapters of the work upon Russia, when all the elements which my friends and myself can bring together shall have been laid before our readers, to enable them to see the grounds upon which the conclusions are based.

For the present, then, I take leave of this volume of M. Le Play, which, though it contains some views of positive geology from which

I differ, must still be regarded as an important addition to the records of physical science, and as possessing much more the character of a good monographic description of a given tract in Russia, than anything which, from the extensive nature of our researches, my friends and myself will ever be enabled to offer.

Permian Rocks.—On its eastern frontier, far removed from the tract to which allusion has been made, the uppermost member of the carboniferous limestones of Northern and Central Russia, distinguished by the presence of multitudes of the foraminifer *Fusulina*, is succeeded by the most widely spread of the Russian systems; to which, from its occupying the whole of the ancient kingdom of Permia, we have assigned the name of Permian. You have been told, that this vast group is composed of limestones, marls, great masses of gypsum, rock-salt and repeated alternations of cupriferous strata; and that it contains a flora and a fauna of characters intermediate between those of the Carboniferous and Triassic periods. The shells are, to a great extent, those of our Magnesian Limestone or Zechstein; and, like the conglomerate of that deposit near Bristol, the Permian rocks are distinguished by the presence of Thecodont Saurians. The interest attached to these vast deposits, which have been spread out on the western flanks of the Ural Mountains, is increased by the inferences which have been drawn, that springs and currents holding much copper in solution must have flowed from the edges of that highly mineralized and metamorphic chain, while the Permian strata were accumulating. But the great value of having worked out a fuller and richer type of a group of strata between the Carboniferous and Triassic epochs than any which exists in Western Europe, will be found in the fossil shells, the plates of which are already far advanced; for, with some species hitherto known in the Zechstein of Germany and Magnesian Limestone of England, we shall publish others which are identical with or analogous to forms that occur in rocks occupying the same geological position in North America, of which I will speak hereafter, and concerning the age of which great doubts had prevailed.

In America, indeed, as in Russia, these beds had been compared with every deposit, from the coal to the Keuper inclusive, whilst in our work they will be shown to have no connection with the New Red Sandstone or Triassic group, but to occupy a definite position.

truly intermediate between that system and the carboniferous. At the same time it is manifest, that although they overlie and are, as they ought to be, very distinct from the Carboniferous system, yet they contain some species of shells which occur in that division. Thus it will be made evident, that after all there now remains scarcely any real difference of opinion on this head between Mr. Phillips and myself (to which I alluded last year); for I learn from him, that in England the analogy between the fossils of the Magnesian and Mountain Limestone obtains to a far greater extent than could be supposed from any published catalogues. I trust, therefore, that the ensuing year will not be without its fruits in the production of new works on the shells of the Magnesian Limestone of our own country; and I am glad to have it in my power to inform you, that Mr. King, the Curator of the Natural History Society of Newcastle-on-Tyne, is preparing some excellent materials for this purpose.

A better acquaintance with the Permian fossils, particularly the prevalent Mollusca, induces me, notwithstanding the arguments I employed last year, to infer that this deposit, so naturally connected through its characteristic fossils with the Carboniferous strata, must be classed with the Palæozoic rocks.* The physical structure of Russia is also greatly in favour of this view; for, in large portions of that country, there is an entire absence of the great rupture between the Carboniferous rocks and the Magnesian Limestone, which is so prevalent in the British Isles. The examination of rocks of this age in North America, to which I shall hereafter advert, leads to the same opinion; viz., that the Permian deposits must be viewed as the fourth or uppermost stage of the Palæozoic series, notwithstanding the occurrence of Thecodont Saurians.

Jurassic, Cretaceous and Tertiary Strata.—Overlapped as these Permian deposits are, in certain tracts of Russia, by red and white marls and sands, we are not positively prepared to state (in the absence of decisive fossil evidences) whether some of them may not represent the Trias; though the fossiliferous limestone of Monte Bogdo, in the steppe of Astrachan, is probably of this age. With the Jurassic strata, however, which follow, and which occur at intervals from 65° north latitude to the countries south of the

* My companions, M. de Verneuil and Count Keyserling, have long entertained the same views as Mr. Phillips on this point.

Crimea, we made ourselves well acquainted. Should the word *Jurassic* grate upon the ears of Englishmen, it is impossible to deny that this geographical term is much more applicable to the strata in question than our own word "Oolitic," which implies a structure scarcely ever seen in beds of this age in Russia. Whether examined at Moscow or on the Lower Volga, they consist of black shales and ferruginous sands, occasionally containing calcareous cement-stones, and thus they present a general lithological analogy to the Lias; a formation, however, which is not represented in Russia, for the fossils are all referable to the groups extending from the Inferior to the Upper Oolite, and many of them are identical with British species.

I must now pass over the Cretaceous deposits which occupy such broad spaces in Southern Russia, the Lower Tertiary beds, some of which, on the Volga, might almost be mistaken for those of Bognor and the London basin, and also the strata of the Miocene age, which occupy wide tracts in Volhynia and Podolia, merely remarking by the way, how the recent discovery in limestone of an herbivorous Cetacean (to which I shall elsewhere allude) is a very important addition to the fauna of that period.

Superficial Detritus—Ural Mountains, &c.—The discovery of accumulations containing recent shells of Arctic species, considerably to the south of Archangel, was important, as showing that the great northern blocks, which overlie them there, were brought to their present positions during a period which differed remarkably from the one preceding it, and also from that which has followed it, in the very general prevalence of a colder climate over large spaces; thus enabling us very safely to infer, that the great erratics of the North were transported in icebergs, which floated in an arctic sea and occasionally grated along its bottom. But this operation, gigantic as it was, had its well-defined southern limits, as is beautifully proved by the general survey of the Russian Empire; in the southern half of which all such erratics cease, and fine black slime (tchornozem) takes their place. Wherever the recent accumulations of the steppes indicate the desiccation of brackish seas, which like the present Caspian were inhabited by Mollusca requiring a warmer climate, then is there also a total absence of great boulders. On this point I would further beg to remind you, that in our examina-

tion of the Ural Mountains, even up to 60° north latitude, my companions and myself could trace no evidence whatever of boulders having been transported from these mountains to great distances upon their flanks; although the peaks rise to heights of 5000 and 6000 feet above the sea, and the chain extends from north to south through eighteen degrees of latitude. In every portion of the Ural Mountains, and on both their Asiatic and European flanks, the detritus is of a purely local character; and in it are occasionally entombed the bones of the Mammoth, *Rhinoceros tichorrhinus*, and other great extinct quadrupeds, mixed up with gold sand and gravel. Transporting ourselves to the south of Russia, we find the upper portion of the cliffs of the Sea of Azof composed of local detritus and clay equally charged with the same remains.

The general examination of Russia proves in the most emphatic manner, that the central masses of her continent, though exempt from all plutonic agency, have undergone grand but tranquil oscillations which have scarcely at all disturbed the physical outlines of the ancient bottoms of the sea—oscillations which have operated in a similar manner over this vast space from the remote Silurian age, to the close of the period antecedent to the historic æra. This survey has also taught us, that the great Russian continent is surrounded by rocks of igneous origin, the eruptions of which have corrugated and diversified certain portions of the surface at different periods.

On her eastern or Asiatic side it has been the wish of my friends and myself to endeavour to read off in the Ural Mountains the effects of such derangements, and to trace the sedimentary deposits of Russia through the mazes of that band of great disturbance. Having so recently laid before you the outline of our views concerning this chain, and being aware that you will soon be in possession of much additional knowledge respecting it from the pen of the illustrious Humboldt, I will confine myself to a single paragraph, by saying that our chief object was to refer these broken and altered masses to their normal types.

We found this highly metamorphic chain, so rich in metalliferous masses, to consist essentially of Silurian, Devonian and Carboniferous rocks, the fossils of which we traced at intervals, notwithstanding the countless ridges of igneous matter and the highly crystalline structure which has been communicated by its eruption to the con-

tiguous sedimentary strata. A short period only has elapsed, since rocks having quartzose, micaceous and gneissose characters would not have been admitted into the same category with strata containing organic remains; but the theory of metamorphism, founded on patient observation and comparison, has prevailed over ancient doctrines. The sedimentary rocks of the Ural being palæozoic, must, indeed, be viewed as among the most ancient of the metamorphic class. Many other crystalline chains are of much more recent age, as long ago, indeed, shown by M. Leopold Von Buch and other observers. Of the truth of this I will first adduce proofs from the Caucasian chain which bounds the Russian Empire on the south. The second illustration of metamorphism will be derived from recent researches in the Western Alps.

Caucasian Chain.—We must now estimate the efforts of an observer, who, in common with Agassiz, does such honour to the little canton of Neufchatel. Though the name of M. Dubois de Montpereux has escaped the notice of my predecessors, an outline of his chief labours was laid before the geologists of France, in 1837, by M. Elie de Beaumont. Attention having been latterly much directed towards Russia and the adjacent regions, it becomes my pleasing duty, the additional researches of M. Dubois having been recently published, and having myself largely profited by them, in the construction of a map of that empire, to invite your consideration to his great work.

From its diversified and varied outline, and its early historical records, no region within the reach of Europeans seemed to have a greater claim upon the combined efforts of geologists and historians than the Caucasus, and yet of no country were we more ignorant. For although travellers have, from time to time, passed over it by one great road or another, from the thirteenth to the present century, and though Kupffer has well described the environs of one of its northern peaks Elbruz, and Eichwald has explored the coasts of the Caspian, we had never had a true picture of the physical geography and varied inhabitants, still less of the geological structure of this chain. No one, in short, struggling with the dangers of climate and uncivilized inhabitants, had so threaded these mountains and defiles as to make us familiar with them*. This Herculean

* Of the scenery, antiquities and costumes of such parts of the Caucasus

task was undertaken by M. Dubois, and most successfully has he executed it, for his work of five volumes is that of a geographer, historian and geologist. The lovers of Homer, Strabo and Pliny will assuredly find in it a mine of classical recollections, a correct identification of ancient sites and vivid sketches of ancient customs, described by Grecian and Roman writers, some of which habits prevail even to this day. Regretting, as we must, that tracts formerly illustrious in song, and many of them still blessed with the richest gifts of nature, should, for the most part, be now tenanted by wild and barbarous tribes, let us the more admire the zeal and energy with which our author, surrounded by privations, has produced so clear a picture of this extraordinary region. Not only does M. Dubois place before us the physical features and the social condition of the various tribes, from the Circassians on the north to the Georgians and Armenians on the south, but he gives us geological sections, maps and descriptions, and thus brings the rocks of these wild and rugged tracts into a clear comparison with known European types.

No country is more entitled to the name of metamorphic than the Caucasus, for M. Dubois proves, that the oldest sedimentary rocks of which it is composed, are scarcely of higher antiquity than the Lias; whilst Ararat, in great part of recent volcanic origin, exhibits on its flanks streams of lava, which must have flowed since the land has assumed its present configuration. So modern is this mountain in the records of the geologist—so venerable as the cradle of the human race.

Let us however cast a rapid glance over some of the chief results of M. Dubois's researches. The central ridges of this mighty chain, formerly supposed to be of primary age, are nothing more than beds of Lias and other strata of the Jurassic age, often so highly altered as to resemble ancient slaty rocks, and occasionally pierced by points of granite and greenstone. These grand and strangely changed strata of the Oolitic series are flanked by huge buttresses of the Cretaceous system, some members of which take the form of fucoid schists

as he visited, including special illustrations of Ararat and the north of Persia, my lamented friend Sir Robert Ker Porter brought away a rich series of beautiful sketches, a few only of which have been published. Though not a geologist, his faithful pencil conveys an admirable idea of the character of the highly inclined and metamorphic strata.

and greensand, whilst others are pure white chalk. Often, indeed, assuming ancient lithological aspects, and broken into striking defiles, covered by beauteous forests, the far-famed Circassia, from one end to the other, is simply the representative, on a grand scale, of our English North and South Downs, with their fringes of greensands*. The explanation of the violent disturbances to which these cretaceous rocks have been subjected, is seen in numerous points of porphyry and other igneous rocks; by which agents, the strata, altered and thrown into highly inclined positions, have been raised to heights of 10,000 feet above the sea. On each side of the flanks of these gigantic mountains, essentially if not entirely composed of the younger secondary rocks, are tertiary basins. To the north they range into the desiccated Caspians, which form the southern steppes of Russia; and to the south they lie inclosed among numerous ridges of plutonic and igneous rocks. Volcanic agency, of the same extinct nature as that with which we are acquainted in Central France, and with which English geologists are now familiar in Asia Minor, from the descriptions of our associates Hamilton and Strickland, abounds indeed throughout many parts of this region. Of the different phases of eruption, the porphyry cone, the crater and the coulée are the evidences; whilst the continued existence of the latent and repressed fires of antiquity is traceable in the naphtha springs of the adjacent lower countries, which are still in action, upon lines running from north-west to south-east, or parallel to the grand line of eruption on which the Caucasus has been upheaved. M. Dubois distinctly marks the great period of elevation of these tracts, when the ridges on the south of the chain began to be the centres of many distinct volcanic vents; and when, by the higher and lesser elevations of districts formerly submarine, the various "amphitheatres" in Georgia and Armenia were formed, all of which he has personally visited. This is truly the region in which, if it be possible, passages may be traced, from rocks of plutonic or submarine igneous agency, to those of pure volcanic and subaërial operation. To decipher order throughout a tumultuous sea of rocks, bristling with extinct volcanoes, is no small

* The botanist will find a striking analogy between the vegetation of the western flanks of the Caucasus and the North Downs (Box Hill) in their respective groves of *Buxus*.

effort; and if M. Dubois should not have completely succeeded in neatly separating the porphyritic and later plutonic eruptions from those of true volcanic age, he has at all events offered proofs, that in many instances the former were covered by the most ancient tertiary accumulations (*quasi* uppermost-secondary), in which vast accumulations of rock-salt, almost mingled with lava of subsequent eruption, seem to favour this hypothesis, that the accumulation of this mineral may in some instances have been connected with igneous agency.

In describing the great elevation which converted the Caucasus from an island into an isthmus, and desiccated large portions of the adjacent seas, leaving them in the condition of steppes, M. Dubois attaches great weight to the evidences of upheaval of the masses in crateriform shapes; and in tracing the succession of the tertiary strata, he shows, that, as a great depression (Colchis) formerly existed between the Caucasus and Armenia, so the beds of rivers which flowed into this ancient gulf, graduate into and form the lowest part of such tertiary basins.

So attractive are his descriptions, that we can actually bring before our mind's eye each successive mutation; either when great and irregular elevations raised up the ancient sea-beds to different levels, or when volcanoes bursting forth (some submarine, and others under the atmosphere) barred up these basins, forming brackish and salt lakes, many of which have since been desiccated. Seeing that he first establishes all the fundamental points of his work on sound observation, and identifies each formation by organic remains, a geologist even may revel with M. Dubois, when, after speaking of the superb garland of volcanic cones, whose summits, ranging from 12,000 to 17,000 feet above the sea, surround the great desiccated basin of Central Armenia, he allows himself to speculate on the letting off of former inland seas and lakes, by the waters of which our progenitors may have been destroyed.

Receding, however, from these views, which connect our science with the history of man, I specially beg to notice the very clear order of the Cretaceous system, first pointed out by M. Dubois on the southern shores of the Crimea; a tract very analogous to the region of the Caucasus, of which, in fact, it is a prolongation. Of the trachytes, trap, pumice, lava and scoriæ of the southern flank of the Caucasus itself, we have no traces in its miniature the Crimea; but a perfect epitome of all the succession of its northern and Cir-

cassian slopes, showing a Jurassic series supporting a very complete Cretaceous system, which the author places in perfect parallel with the beds of similar age in Europe, with which he is acquainted.

In referring you to his table which marks twelve distinct stages in this cretaceous system, the uppermost of which contains *Trigonia* and *Ostrea gigantea*, and the lowest of which is an undoubted type of what foreign geologists call the *Terrain Néocomien*, I would here suggest that the greater part, if not the whole, of the series may be paralleled in the south of England, and that too without consulting other sections than those described by Dr. Fitton, and the natural phænomena which he has so faithfully represented. The uppermost seven divisions of the Crimea are all evidently referrible to our chalk and chalk marl, and contain many of our well-known fossils, the only striking difference consisting in the association of Nummulites and *Cerithium giganteum*, with the *Trigoniæ* and *Ostreæ* of the uppermost chalk. The beds 8 and 9, *Craie chloritée* and *Grès vert*, containing, amid *Exogyræ* and some cretaceous fossils, the *Pecten quinque-costatus* and *P. orbicularis*, most unequivocally represent our Upper Greensand or "malm rock." The marly strata which lie beneath such beds are therefore, we may fairly presume, the representatives of the English gault; and, lastly, the yellow limestone and sand, immediately beneath it, which forms the Neocomian of M. Dubois, may, after all, be considered the equivalent of our Lower Greensand, or the expansion of its lowest beds which pass into the Wealden.

I have always regretted that so few foreign geologists have obtained an adequate idea of the dimensions and importance of the third or inferior division of lower greensand as exhibited on the southern shores of the Isle of Wight (Atherfield Rocks). In France the formation has been little recognized beyond the Boullonnais, where it has already almost lost its distinctive characters, and where there are no longer the divisions of upper, middle and lower beds, each, as shown by Dr. Fitton, characterized by peculiar fossils. In the south and east of France, where upper greensand and gault abound, it now appears* that the base of the Cretaceous system is composed of limestones identical with those of Neufchatel, and which, participating in all the flexures of the chalk, are usually broken off, as in the Crimea, from the Jurassic system.

* See discourse of last year.

It has been suggested that the Neocomian limestones may represent the Wealden of British geologists. But this is not, so far as I can judge, safe reasoning; for the latest researches of Professor Owen would lead me to believe, that the Saurians of that great estuary formation are much more nearly allied to those of the Oolitic or Jurassic epoch than to those of the Cretaceous period*; and Agassiz has assured us that the fishes of the Wealden are entirely distinct from those of the chalk.

I have before expressed my opinion on the head of Neocomian, both to French and English geologists†, and I now repeat it, more however as a stimulus to those who have the means to settle this point accurately, and not because I entertain any objection to the foreign use of the word. The term may, indeed, be very well and appositely used in reference to the deposit throughout central and eastern Europe, where its lithological characters are so different from what is I presume the English type; and where they have been so well described by Swiss and French observers. I seek merely for the establishment of the truth; and I again ask if the Neocomian of Neufchatel and the Crimea be not the equivalent of the lowest Greensand of England, and of the *hils-thon* of Römer in Hanover? On revisiting the Isle of Wight last spring, in company with my friend Count Keyserling, and on finding in these beds many true Neocomian species, I adhered to my old opinion‡; and I now put this question in the hope that it will be completely answered through the labours of English geologists, and particularly of Mr. Austen, who has, I know, commenced an inquiry into this subject, and whose acquaintance with fossil shells and habits of field-research well qualify him for such a task.

There is yet one point connected with the researches of M. Du-

* See note p. 36, on the supposed Wealden of the Highlands.

† In referring to an opinion which I expressed at the meeting of the Geological Society of France in 1839 (Bull. Soc. Geol. tom. x. p. 392 *et seq.*), I beg to say, that it is specially to the Greensand as the chief equivalent to which I refer.

‡ Since this Address was read I have received a letter from Count Keyserling, dated Petersburgh, March 7, in which he acquaints me, that in a mass of shelly rock from Kyslavodsk in the Caucasus, which has been considered Neocomian, he has detected the same species of *Thetis*, *Trigonia*, and other fossils as those which we collected together in the Lower Greensand of the Isle of Wight.—*March 31st.*

bois on which I beg to touch, from the admiration I entertain for any one, who pursues science for its own sake, and achieves durable results by his own unassisted endeavours. Occupied during ten years of his life as an instructor of youth, M. Dubois had no sooner realized a small independence than he resolved to enter upon this arduous undertaking. Repelled, in the first instance, by the war with Turkey and by the plague, he fortunately retired upon Berlin, where, passing two years in the admirable school of geologists of which that capital boasts, he once more set forth on his grand enterprize, with no other recommendation than that which his good name, and a short memoir on Volhynia and Podolia, had acquired for him, and no other means than his own very moderate private fortune. Disposed, as it has always shown itself to encourage science, the Russian government was no sooner acquainted with his designs, than it offered him conveyances in their ships of war, and subsequently gave other encouragement. Hence M. Dubois was enabled to reach parts of Circassia which would otherwise have been inaccessible; and thus he entered upon his remarkable journey. Revisiting the Crimea and parts of the south and north of Russia, he returned to Berlin, after an absence of four years, laden with much precious knowledge. But how was he to put this before the world? Not alarmed at the prospect of publications, from their descriptive nature necessarily very expensive, M. Dubois, encouraged by M. de Buch and M. E. de Beaumont, commenced the preparation of his works, of which five volumes and a splendid atlas have already been issued; and as these are to be followed by other works, it is to be hoped that all the productions of this spirited author will be adequately and liberally purchased by the discerning portion of the public. I have the less hesitation in making this appeal to my countrymen, because I really believe that the high class of merit which belongs to the researches of M. Dubois is yet known to very few of them*.

Asia Minor.—It is with great satisfaction I am now able to refer you to the work of one of our own Secretaries, as having connected the region described by M. Dubois with the southern Mediterranean types. Mr. W. Hamilton, who, with Mr. Strickland (his associate during a portion of his time spent in the East), has laid be-

* For the general geological views of M. Dubois, see his letters to M. E. de Beaumont, 'Bulletin de la Soc. Geol. de France,' vol. viii. p. 371 *et seq.* His researches have been justly appreciated in France.

fore you in former years a memoir on the geology of Asia Minor, including the Catacecaumene, a tract of extinct volcanoes, has now published an account of all his travels. Amidst a number of new facts which he has brought together to throw light on the geography and history of tracts held in veneration both by classical and biblical antiquaries, he has added much valuable geological information to our previous stock of knowledge of these little-explored countries, and for the greater part unknown to the scientific. In Armenia he shows the existence of vast basaltic plateaus within the visual horizon of Ararat, where he found deposits of tertiary shells extending over a surface of from 50 to 100 miles, at an altitude of upwards of 6000 feet above the sea; a phænomenon quite analogous to one of those instanced by M. Dubois: and they both demonstrate to what great distances the powerful action which elevated Ararat and the Caucasian chain extended. Mr. Hamilton points out that the limestone formations, probably cretaceous, between the Caucasus and Erzerûm are penetrated at numerous localities by basalt and trap; whilst along the southern coast of the Black Sea the rocks are shown to be chiefly igneous towards Trebizond, and cretaceous as they approach Sinope. The mountains of Pontus, from the Black Sea to Amasia, are composed, it appears, of semicrystalline limestone, accompanied by intrusive igneous rocks; but the former passes to the west or towards Galatia into red sandstone, containing numerous deposits of rock-salt. Lastly, the central plains of Asia Minor, occupying a great portion of Galatia and Phrygia, are supported by the semi-crystalline limestone, containing Nummulites (so well known in the Mediterranean basin, and which has been generally referred to the Cretaceous age), accompanied by numerous igneous outbursts, and consisting of wide expanses of white tertiary lacustrine limestone, some portions of which advance even to the northern range of Mount Taurus. Such extensive data are, you will agree with me, of essential value in enabling us to form a sound geological theory respecting the ancient condition of the crust of the globe, and in convincing us that tertiary sediments of lacustrine origin occupy areas of great extent. Mr. Hamilton has furnished the most decisive proofs that, in such periods, the physical conditions of the surface were fast approaching to those which now prevail. I must, however, request every geologist who wishes to obtain a correct acquaintance with Asia Minor, to consult the well-filled volumes of our Secretary,

which, pregnant with valuable truths, worked out with energy and fidelity under numberless difficulties, will be placed, I fear not, among the works which have considerably extended the boundaries of positive knowledge.

Turkey in Europe, Servia, &c.—Our indefatigable friend M. Boué has the merit of having united the distant regions of Asia Minor with Western Europe. Courting, as he has always done, a line of useful research, however difficult and repulsive, it was enough for M. Boué to know, that all the great tracts to the south of the Danube and beyond the countries of Transylvania, which he had formerly described, were untrodden by geologists. Residing, I believe, more than two years in these rude provinces, he made himself master of their statistics and geography; and, publishing a geological sketch of Turkey in Europe, he has also furnished us with a geological map of that country*. Of palæozoic rocks, as distinguished by their fossils, Turkey affords few traces beyond the small tracts at Constantinople occupied by true Silurian strata, which Mr. Hamilton and Mr. Strickland made known to us. Great masses of the inferior rocks are stated by M. Boué to be in such a metamorphic and crystalline state, and to be so penetrated by a great variety of intrusive rocks, that it is very difficult to determine their age. With some very doubtful exceptions, no secondary rocks, in short, can be recognized as of higher antiquity than the Cretaceous system, which having, for the most part, the crystalline character which it puts on in all the Mediterranean countries, is still divisible into Lower and Upper deposits, the former consisting of schists and sandstones with fucoids, which represent our greensands, and the latter of a white marble with nummulitic strata, the equivalent of our chalk. Overlying these, our author mentions and lays down upon his map no less than thirty tertiary basins, thus showing a great analogy to Asia Minor. For such marked results our special acknowledgements are due to M. Boué, than whom no one has accumulated a greater number of facts in many parts of Europe; his numerous and difficult journeys having been performed entirely at his own cost, and chiefly for the pure love of geology.

* A geological map of a part of Servia and Albania, prepared by Colonel Lassie, from the observations of M. Visquenil, has, by the assistance of M. Boué, completed our acquaintance with the geology of this distant part of Europe.

Piedmontese Alps.—In the north of Italy and the Western Alps, considerable advances have been made by the labours of M. Sismonda, who is engaged in the formation of a geological map of the Piedmontese territory, which, with the map of Sardinia by the Cavalier Marmora, will give a complete view of the structure of the Sardinian dominions. To accomplish this, M. Sismonda has been labouring during the last ten years; and I am led to believe that in about two years his great map will be finished. In the mean time, and in addition to various memoirs with which you were previously acquainted, he has recently published descriptions of the Piedmontese Alps. Dividing the great mass of crystalline rocks, he shows that the inferior portion may really be called primary gneiss and mica schist: although other rocks, which have to a great extent the same lithological characters, but which alternate with quartzose grits, and repose unconformably upon the first series, are truly metamorphosed aqueous deposits. Considering the great derangement and changes to which these latter rocks have been subjected, the author does not, however, attempt to fix their age. On this point I may be permitted to observe, that Professor Sedgwick and myself have pointed out the presence of Producti and Encrinites in crystalline rocks of the Eastern Alps; and hence it is probable that some of these masses, in which no organic remains have yet been discovered in the Western Alps, may occupy the place of palæozoic deposits. Again, a third group is, by its mineral aspect, also apt to be confounded with the primary rocks; and yet, as has long been known, the Lias and Jurassic strata are included in it.

Since the day when M. Elie de Beaumont first exhibited to the astonished geologists, Belemnites in chloritic and micaceous schist! these highly altered Lias rocks have excited the most lively interest; more particularly as the Belemnites were found associated with plants which M. Adolphe Brongniart identified with species well known in the Carboniferous deposits. Anxious to explain this apparent anomaly, M. Sismonda, who, on a former occasion as well as on a recent one, was the companion of M. de Beaumont, following these masses from Mont Blanc to the department of the Lower Alps, where they are most charged with fossils, has arrived at the conclusion, that whether crystalline limestones, quartz rocks or quartzose conglomerates, all these rocks belong to the great Jurassic series, from the Lias to the Portland stone inclusive; the re-

spective formations being more or less metamorphic as they approach to, or recede from great centres of plutonic eruption.

On the curious and long-disputed point of the relations of the beds with Belemnites to those with coal plants, M. Sismonda, sustaining the views of M. de Beaumont, asserts that the sections fairly exhibit alternations, and that the difficulty cannot be set aside by supposing one of those reversals *en masse*, so common in mountain tracts, and by which older strata are often superposed on younger. M. Sismonda agrees, therefore, with M. de Beaumont in believing that the plants in question lived near the spots in which they are now found, and during the same period as the Belemnites of the Lias. It remains for naturalists to explain how certain plants, whose forms indicate a climate of high temperature, may have continued to grow during successive periods in favoured spots, though their congeners had long been destroyed in other parts of the world.

Proceeding upwards from the Lias as a base, and seizing here and there upon remnants of the strata from which the impress of their origin has not been obliterated, M. Sismonda refers certain limestones, grits and schists to the Great Oolite. Another group, composed of grits, quartzose conglomerates, psammites and schists, in some parts metamorphic and unconformable to the preceding, (and which, extending over the Genevese and Piedmontese Alps, is also largely exhibited in the Alps, in the Col di Tenda, and in the Tanaro) is re erred by our author to the age of the Oxford clay ; though preceding geologists, misled by the red colour and other characters, had referred it to the New Red Sandstone. Among the uppermost deposits of the oolitic series of the Alps, M. Sismonda recognizes in certain limestones highly charged with zoophytes, the representatives of the Upper or coralline Oolites and Portland rock of England. In the Apennines of Liguria he has observed the Jurassic formations covered by the cretaceous rocks with fucoids ; and the greensand of Nice, formerly described by Sir Henry de la Beche, is now shown to repose on the Neocomian limestone of foreign geologists, a formation which, as has been stated, there is reason to think is the representative wholly or in part of our lowest greensand.

Nor has M. Sismonda neglected the Tertiary deposits ; for by the aid of fossils he has clearly established, that two only of the great epochs of Mr. Lyell are represented in Piedmont ; viz. the Miocene, the strata of which are extremely dislocated, and the older Plio-

cene or sub-Apennine, which is for the most part horizontal, marking, however, by partial breaks, the period of elevation of the Eastern Alps, whilst the Miocene beds are thrown up in the direction of the Western Alps. In reference to this point, M. Sismonda has traced in the Alps, the signs of five distinct and well-separated periods of revolution or upheaval; and among the agents which have effected the changes, he particularly shows, that whatever part the serpentine may have played in these convulsions, it existed before the accumulation of the Miocene deposits, since fragments of that rock abound in the highly inclined pebbly beds of the Superga at Turin.

Such, Gentlemen, is a very brief sketch of some of the prominent results of the researches of M. Sismonda; and admiring, as you must, the ability and perseverance with which he has accomplished them, you will, I am sure, feel gratified in seeing that the sedimentary rocks named by the early school of British geologists in our own little island, have served as the base-lines or types by which order has been elaborated in a great disturbed region, where the chaotic assemblage of rocks and their crystalline and metamorphic characters seemed to forbid the hopes of any such comparisons.

North American Geology.

In considering this branch of my subject it will not be expected that I should attempt to give even the slightest sketch of the labours of all the men of science who constitute the enlightened school of geologists which has arisen within the United States. Possessed of a theatre of research in which natural phænomena are developed on a gigantic scale, the rapid progress of our transatlantic brethren has been most surprising; and the triumphs which they have achieved are doubly gratifying to ourselves, as they are founded, for the most part, on comparisons of their own rocks with those which have been classified in the British Isles. The past year has been unusually prolific in such communications, and I have therefore confined the following remarks to those researches which have been distinctly brought before us, referring my hearers who wish to study the subject of North American geology *in extenso*, to the original works, already forming a considerable library, including a vast number of communications which are to be found in that excellent periodical, the 'American Journal of Science,' conducted by Professor Silliman.

Palæozoic Rocks.—The value of the remarks of Professor W. R. Rogers and his brother Professor D. H. Rogers* (one of our own fellows), in working out the complicated folds and contortions of a large region of palæozoic rocks, is well known to every English geologist who has visited North America. Placed at the head of the State Surveys of Pennsylvania and Virginia, these gentlemen took the occasion of the last meeting of the British Association to send to this country a joint memoir, entitled, "On the Physical Structure of the Appalachian Chain, as exemplifying the Laws which regulated the elevation of great Mountain Chains generally."

The Appalachian chain, including the Alleghanies, is the great back-bone of North America, having a length of nearly 1200 miles, with average width of about 100 miles, and it is essentially composed of one great mass of palæozoic deposits conformable to each other, which these authors and others have identified with Silurian†, Devonian and Carboniferous deposits.

And here an acknowledgment is justly due to our able associate and countryman, Mr. R. C. Taylor, well known to us before he left this country for the United States, as the author not only of good memoirs on the Crag of his native county, Norfolk, but also of an accurate survey and model of a part of the Glamorganshire coal-field. Mr. R. C. Taylor has, in fact, published several valuable sections and views explanatory of one of the coal-fields of Pennsylvania, in a separate work on that country.

Extending from north-east to south-west, the older rocks of the Appalachian chain have been thrown into a number of anticlinal ridges and synclinal valleys from 100 to 150 miles in length, and all more or less parallel to each other, but with certain deviations from rectilinear to curved directions; and of these Professors Rogers constitute nine principal groups, in five of which the axes are straight. Describing many of them, the authors show, that as the folds approach to the south-east, where igneous and crystalline rocks occur, convolutions are much more rapid, accompanied by many breaks

* See his Report on American Geology, published in the volumes of the British Association.

† The lowest rocks of the Appalachian chain were placed in parallel with the Silurian rocks by Mr. G. W. Featherstonhaugh in 1836. See Geol. Report. Washington, 1836, p. 101.

and by complete inversion of the beds. This latter phænomenon is identified with that which has been recognized on the flanks of the Alps and other eruptive continental chains, where the older strata are incumbent on younger, and on the western flank of our own little Malvern Hills, where there is, as before said, a complete illustration of inverted dip. Seeing also that, in proportion as they recede from the main axis the folds are less abrupt, and gradually open out into broad and flattened anticlinals, which entirely die away at a certain distance from the crystalline and intrusive rocks, or towards the interior, the authors formed a theory which they conceive to be applicable to the bending and elevation of strata generally.

Comparing the undulations which mark the axes with the undulatory motion of the earth during earthquakes, they believe that all the grand ancient flexures of North America were produced at one time, and at the termination of the carboniferous æra, up to which period they were all beneath the sea, and consequently still in a flexible condition. These sediments were, it is supposed, subjected to flexures by the invasion from below of molten matter; and the peculiar and numerous convolutions are explained by calling into play an upheaving, wave-like oscillation, accompanied by a tangential or lateral pressure upon flexible masses which reposed upon a semifluid matter. English geologists will recollect that, in our account of the carboniferous strata of North Devon, Professor Sedgwick and myself distinctly referred their multitudinous flexures to lateral pressure; because in this case we had the eruptive wedge-like chain of Dartmoor on one flank and the older sedimentary ridge of the North Foreland and the Quantock Hills on the other, forming a resisting buttress, between which the intervening strata might very well be squeezed into their contorted shapes. In the American case lateral pressure was, it appears, applied on one side only of the bent strata; and hence the phænomena described, appear to me to indicate simply a dying out in a certain direction of the disturbing powers.

Admiring the positive geological results which have been derived from the survey of Pennsylvania, I regret that the theoretical inductions of the authors were suddenly brought before a body at Manchester unacquainted with the country which the authors had patiently worked out, and on which their reasoning was mainly founded. Unprovided also with the remarkable maps which have been prepared by Professor H. Rogers and his assistants, and with-

out diagrams to illustrate the mechanical principles it involved, the geologists at Manchester could ill judge of the merits of the theory. A better acquaintance with the facts as well as with the objects of that memoir, induce me, however, to view it as a praiseworthy effort to establish laws of phænomena regarding subterranean movements; from a careful survey of the actual positions and relations of the masses moved in a definite but sufficiently extensive district. The manner in which these laws are expressed is perfectly (it must be admitted) in the spirit of inductive philosophy; and the intentions of the authors in presenting them, was truly stated to be "to call the attention of British geologists to analogous phænomena, which the authors think they detect in mutually parallel axes of some of the most interesting districts of Great Britain and the Continent." It is therefore my duty to invite your attention to the views which this communication embraces; and whatever may be your conclusions respecting the theory, to request you to bear in mind, that it was suggested by a wide and successful field-survey which is replete with sound research, and that the memoir was generously confided to the friendly feelings of the geologists of England.

I would next advert to the labours of Dr. Dale Owen of Indiana, who has presented this Society with a paper on the geology of the Western States of North America. In this memoir Dr. Owen comprises not only the results of his own observations since 1834, but also those of Dr. Troost* and Dr. Locke, the state geologists of Tennessee and Ohio. This memoir affords a general description of a vast country lying between 35° and 43° north latitude and 81° and 91° west longitude, including the States of Illinois, Indiana, Ohio, Kentucky, and Tennessee; throughout which enormous area, the deposits are stated to belong chiefly to the Carboniferous and Silurian systems.

Of the exceptions to this distinction, consisting of strata of the age of the Cretaceous system which overlap these palæozoic rocks on one frontier, and of other overlying deposits, to all of which the author alludes, I need now take no notice. Adverting to certain

* In his Sixth Geological Report to the General Assembly of Tennessee (1841), Dr. Troost divides the Transition rocks of that state, and comparing the fossils, he distinctly refers a large portion of them to the Silurian system, saying that there are at least three or four divisions of that system in Tennessee.

inferior masses beyond the Cumberland mountains which dip towards the granite (the phænomenon to which the Professors Rogers allude), it is shown, that these dislocated bands are surmounted by a series of strata often containing abundance of organic remains. One group of beds of shale, limestone and marl in the great Ohio valley, and estimated to occupy a surface of 10,000 square miles, is referred, from its fossils, to the Lower Silurian rocks. The next overlying mass consists, in great measure, of compact limestones, which mineralogically might be mistaken for the Great Scar or Mountain Limestone, but which the author now unhesitatingly compares with the Wenlock formation, pointing out that it is covered by other limestones and shales, and then again by a peculiar sandstone, the whole of which represent the Lower, Middle, and Upper Ludlow rocks. This vast series, characterized by Silurian fossils, sinks under enormous troughs of strata which are referable to the Carboniferous system, their base being composed of two bands of limestone, one of which (containing Pentremites, and called the Pentremital limestone) is compared with the Mountain Limestone of England, though from the previous observations of Dr. Troost this point may be doubtful*. Can the lower limestone and part of the supposed Upper Silurian represent the Devonian? Lastly, reposing upon these, are two carbonaceous masses of prodigious extent, one of which, as large as Great Britain, is commonly known as the great Illinois coal-field; the other, occupying parts of six states, covers an area of at least 50,000 square miles.

In estimating the value of this memoir, I must express on the part of this Society our obligations to Dr. Dale Owen, not only for his lucid description of the order of succession in those great and important limestones, and for the clear sections by which they were accompanied, but also for the very instructive suite of fossils characterizing each stratum, which he has presented to us. I have, on a former occasion, alluded to the value of similar contributions upon the older Rocks from the northern portion of the United States by Mr. Hall; and I cannot but anticipate that the close study of the palæozoic fossils of America and of Russia, which have found their way into our museum within the last two years, will lead to results highly interesting to the naturalist, by showing variations of the same species when found in very distant localities; and most important to

* See Troost's Report, 1841, p. 21.

the great principles of geological classification, which, when rightly understood, can only be based upon the admission of such variations in widely remote contemporaneous deposits.

In presiding over the Section of geologists at the Manchester Meeting of the British Association, when this memoir was first introduced to the notice of my associates, I ventured to commend it for its truthfulness of research and practical value, and I was happy to find, that it was received in a similar spirit by this Society, the members of which will doubtless take a still deeper interest in it when they know that its author received his geological and chemical education in University College under the tuition of our lamented secretary, Dr. Turner.

Theory of the Origin of Coal.—American and European Evidences compared.—At the last Anniversary we were aware, from the independent evidence of Mr. Lyell, that both the bituminous and anthracitic coals of Pennsylvania were underlaid by *Stigmaria ficoides* and fireclay; and we have now before us the result of the labours of our associate Mr. Logan in the coal-fields of Pennsylvania and Nova Scotia, in examining which his chief object seems to have been to ascertain whether the facts relating to the theory of the origin of coal, as seen in North America, were analogous to those to which he has so successfully directed attention in England.

Availing himself of the prior researches of the American geologist, Professor H. Rogers and his assistant surveyors, who had prepared the valuable map of Pennsylvania above alluded to, Mr Logan has laid before us a very clear sketch of the general relations of the Pennsylvanian carbonaceous deposits, and of their chief convolutions. Since that time the Governor and legislature of the Canadas have wisely selected this well-trained field geologist to execute a mineral survey of the whole province; and I am happy to acquaint you that he has already commenced his task in a very effective and vigorous manner, by laying down as the base-lines of his work some of the great anticlinals and synclinals of that region, and by connecting them with the already described feature of the United States. In comparing the coal-field of Pennsylvania with those of South Wales, with which he is familiar, Mr. Logan states, that he almost invariably detected beneath each anthracitic coal-seam a bed of fireclay or argillaceous materials filled with *Stigmaria ficoides*. In his description of the coal-fields of Nova Scotia, which

have not yet been fully developed, but among which we hear of one bed of clear coal twenty-four feet thick, and affording 250 tons daily, Mr. Logan states he had also detected the *Stigmaria ficoides* in similar underclay. With such extended observation spread out before them, the evidences in which all seem to point one way, young geologists may well be led to suppose that the theory which, if I may so speak, has recently been rendered fashionable, of the origin of coal by subsidence of vegetable matter *in situ*, must be considered established as of general application. I, however, adhere to the cautionary remarks which I ventured to make last year, and will now endeavour to impress upon your minds the inapplicability of such a theory, however true under limitations, to large portions of the carboniferous strata in different parts of the world.

Since our last Anniversary statements have appeared in our own country, both supporting and impugning the probable truth of the theory. The last meeting of the British Association being held at Manchester, geologists were there assembled in the centre of a tract appealed to with great reason by the supporters of this theory as containing many proofs of its truth; for, in the immediate vicinity of that town there occur, as you all know, the beautiful examples of vertical stems of large trees apparently in their original position, which were formerly described before this Society. After giving an elaborate and satisfactory account of the great Lancashire coal-field, showing that its lowest members, formed on the flanks of the Penine chain, and subordinate to the millstone grit, contain marine shells analogous to those of the Mountain Limestone series, and stating that they are surmounted by a middle and an upper group, the former constituting the richest coal-field, Mr. Binney describes in great detail the composition and contents of all the numerous roofs and floors, as well as also of the coal-seams, which are included between them. He shows also that the roofs vary in their nature at different places, even over the same seam, and contain the remains of many vegetables, sometimes, as near Manchester, in vertical positions, *Sigillariæ* being in such cases a most abundant plant; other roofs of black shale in the lower field are loaded with *Pectens*, *Goniatites*, *Posidonia*, and fishes. The coal-floors, on the contrary, present a much greater uniformity of structure, fireclay similar to the underclay of Mr. Logan being most

abundant; though it is admitted, that a different or siliceous clay also frequently occurs, and that two instances are known where the coal rests at once on coarse quartzose sandstone. Seeing, that with one exception, all the floors throughout an estimated thickness of near 5000 feet contain the plant *Stigmaria ficoides* usually with its leaves attached,—that both the roofs and floors indicate a very tranquil method of accumulation,—that the coal is free from admixture of foreign or drifted materials, and that large trees frequently stand upright, this author is induced to believe that the vegetables out of which the coal has been formed, grew upon the spot.

At the same meeting this view was contested by Mr. W. C. Williamson, also well acquainted with the structure of the country around Manchester. His chief arguments were, however, derived from other tracts, and they assisted in proving,—1st, the frequent association of marine shells with coal (as at Coalbrook Dale, and in Yorkshire); 2ndly, the very triturated and broken condition of the plants, as well as their great intermixture in the sandstone and grits, coupled with the fact that large quantities of vegetables are often matted together with marine and estuary shells, phænomena indicative of drift. Admitting that the floors of the coal or underclay present a great uniformity both in the absence of other plants and in the almost general occurrence of the Stigmaria, Mr. Williamson allows that a plant, found so very generally in such a position, may have grown in estuaries into which the other vegetables were drifted. Acknowledging that the drift theory is open to some objections, he stated that one of the greatest of these is, in his opinion, the extent and uniformity of some of the thin seams of coal. On this point, however, I must be permitted to say, that, if admitted, the difficulty must be applied to numberless other deposits of all ages, which every one knows must have been accumulated under water. Subaqueous action of a tranquil nature is, it appears to me, precisely the agency by which we can satisfactorily explain the uniformity of many thin layers containing vegetables which are extended over wide areas, as in the copper grits of Russia before alluded to. By what other possible means, for example, can we explain the wide extent of the thin copper slate of Germany with its associated fishes on the still thinner bone-bed at the base of the Lias? So far then from being a phænomenon which invalidates the formation of coal

under water, it seems to me, that the very fact of a thin and equable deposit is an almost impossible condition, if we insist exclusively upon the submergence of forests or jungles *in situ*, in which considerable irregularities of outline must in all probability have prevailed.

On my own part, and that of my fellow-travellers in Russia, I have brought before this Society what we consider strong evidences against the too general adoption of this favourite theory. We have told you that in many instances the *Stigmaria ficoides* occurs in loose and incoherent sands, as well as in shales, and is frequently present where no coal is seen; but what we chiefly insist upon is, that all the coal-seams of the South of Russia, without exception, alternate repeatedly with beds of purely marine origin. In one section of the Donetz coal-field it has been stated, that at least twelve beds of marine limestone alternate in one vertical section with thirteen seams of coal and numerous bands of sandstone and shale, in which many species of plants, besides Stigmariæ, are confusedly heaped together. But we need not go to Russia for such examples. The whole of the mountain limestone or lower coal series of the north of England is charged, though not to so great an extent, with proofs of the alternation of marine deposits with coal and its associated sandstone and shale.

The coast of Northumberland, to the north of Alnwick, presents evidences of thin seams of coal resting at once on sandstone, and intimately connected with limestone full of sea shells. Advancing northwards to Berwick, and to beyond the Tweed, purely marine strata re-occur, charged with still more carbonaceous matter; and, in the same series on the north-western parts of England, we have frequent examples of the persistence of what must be called exclusively marine conditions. Throughout that vast succession of beds, all the animal remains with which geologists have become acquainted, occupying many distinct stages, have lived in the sea, whilst the plants, so far as I have been able to observe them (broken into fragments), consist of many species irregularly heaped together, the whole, together with the sands, grits, pebbles and shale, offering the clearest signs of the drifting action of water.

On the subject, then, of the origin of coal, it would appear, that as our inductions can never be sound, if they repose upon one class

of phænomena only, so do some coal strata offer indications of the truth of the hypothesis, that in large tracts of the world, the mineral was formed from vegetables which were washed into bays and estuaries, and often carried far into the then existing seas. In other instances, flat and marshy tracts rich in tropical vegetation, being subjected to gradual depressions, may have been converted into lagoons and swamps without any direct encroachment of the sea; and in this peculiar condition (subjected, however, in all cases, to entombment beneath those waters in which the overlying sandstone and shales were accumulated), oscillations of the land may have raised the beds at intervals, again to be fitted for the growth of marshy vegetables.

In geology more than any other science, it must be our constant endeavour to unravel phænomena which at one time seemed inexplicable, and often opposed to each other; but with new discoveries the difficulties vanish, and the apparently conflicting testimonies are found to be in perfect harmony with the order of changes, which the surface of the globe has undergone. I repeat, therefore, my belief, that, whilst coal may have been formed in many localities by subsidence of vegetables on the spot on which they grew, as first suggested by Brongniart, MacCulloch and others, its origin unquestionably is also due, and over very large territories, to plants having been washed into estuaries and seas, and there equally spread out in successive layers with sand and mud.

Gypsiferous Rocks in North America.—Having now disposed of all the subjects relating to the known deposits of decided Palæozoic age in North America, I will endeavour to show how the examination of one continent throws light upon the structure of another, by inviting your attention to the great Gypsiferous deposits of North America, to which in treating of Russia, I have already alluded.

The gypsiferous strata of Nova Scotia, with their associated sandstone, shale, and fossiliferous limestones, were at first referred by Mr. Logan to the triassic period; an inference which he drew from the general character of the fossils, and their dissimilarity, as a whole, to those of the Carboniferous rocks of that country. This opinion, however, is one from which I know this author receded, upon finding

that some of the shells which he had brought home were recognised by M. de Verneuil and Count Keyserling, to be identical with species from the Permian deposits of Russia.

This comparison with the Russian strata has, indeed, received so much illustration by the arrival of a large assemblage of fossils brought from numerous localities in Nova Scotia by Mr. Lyell, and which he has obligingly submitted to the examination of M. de Verneuil and myself, that I have not much doubt of these gypsiferous deposits and associated limestones of Nova Scotia, being absolutely the same as the Permian rocks of Russia. Even lithologically there is the greatest similarity, whether in the large rock-masses of gypsum, red and green marls, conglomerates and sandstones, or in the magnesian and sandy limestones; and when we compare the fossils submitted to us, the parallelism is as firmly established as can be, between any two groups of the same age in distant localities. It is not merely that these American strata contain a few species identical with forms which typify the Magnesian Limestone of England, the Zechstein of Germany and the Permian rocks of Russia, but still more that such beds immediately overlying the carboniferous deposits, and even, according to Mr. Lyell, partaking of some of their flexures, should be found to contain exactly the same distribution of genera, and as near as possible the same proportions of species in each genus as in the synchronous deposits of Europe! Again, the fossils of this group are, for the most part, as badly preserved and limited in species in America as in Europe, and the striking agreement of those which can be detected is therefore the more remarkable. Even in negative proofs the similitude is great; for wherever these deposits have been traced eastward through Europe and to the confines of Asia, they have been found to be singularly deficient in chambered shells, and such Mr. Lyell finds to be the case in the various localities examined by him in North America. But having already sufficiently called your attention to the striking points of agreement between the American and Russian formations, I anticipate the pleasure you will shortly experience when Mr. Lyell brings the subject, as he intends to do, before the Society.

Seeing the great variety of lithological aspects of these strata in

Russia, and that the flora as well as the fauna are of a type distinct from those of the carboniferous age, we proposed the name *Permian*, a term which I trust may be considered more applicable to the equally diversified deposits of North America than "Zechstein" or "Magnesian Limestone,"—names which point to one member only of this complex series as seen in Russia, and where it occupies a region larger than the whole kingdom of France!

Mr. Logan having also stated that he found slabs in some rocks in the bay of Fundy, which he considers to be of the same age, and which exhibit footmarks on their surface, is it possible, I would ask, to connect with the same formation, the red and green marls of the valley of Connecticut, though distant 400 miles, in which Ornithichnites occur, and which also contain remains of Palæoniscus, a genus of fish very characteristic of the Permian rocks? To this question we shall again revert under the head of Palæontology, in considering the Ornithichnites of Connecticut*.

Newfoundland.—This very ancient British colony, viewed until recently as a mere fishing station, but now rising rapidly into importance through its internal sources, has recently undergone a geological survey by one of our members, which demands notice in this portion of my Address, because the author, Mr. Jukes, is of opinion, that this island contains no strata of younger age than the Carboniferous. The eastern parts are, it appears, composed of very thick deposits of slaty rocks, sandstones and conglomerates, which are divided into upper and lower masses. They are penetrated by different igneous rocks traced from north-north-east to south-south-west in a number of anticlinal and synclinal lines. Great masses of the central tract are usurped by granite and various igneous with metamorphic rocks, which are followed on the west by

* Since the Anniversary of the Society the fossils of the gypsiferous rocks of Nova Scotia collected by Mr. Logan have been examined by Mr. Phillips, who is of opinion, that they bear a most striking analogy to those of the Magnesian Limestone of England. It is satisfactory, therefore, to know that the beds containing the footmarks are proved to be of the same age with the gypsiferous rocks by the presence of the same group of fossils. Mr. Logan alludes to plants which I have not seen, and the exact comparison of these and others collected by Mr. Lyell with Permian types is still very desirable.—April 1st, 1843.

a band of gneiss and mica schist with crystalline limestone*. To what epochs any of the slaty rocks belong, has not been determined, as no organic remains have been found in them, but on the western shores, this ancient and crystallized series is overlapped by red sandstone, shale, gypsum, beds of coal subordinate to shale, marl, yellow sandstone and grit. I here quote the ascending order which Mr. Jukes assigns to the strata; but as he admits he never could observe consecutive sections, is it not possible that the great gypsiferous beds of Newfoundland may occupy the same place in relation to the coal-fields as in the opposite shores of Nova Scotia, and like them represent the Permian deposits? In fact, Mr. Jukes candidly states, that the gypsiferous, red and inferior portion of the coal formation (as he classes it) is so similar to the New Red Sandstone of England, that he was at first sight tempted to give it that name. Now as these rocks are seen in one section only beneath the coal, the following hypothesis may be adopted: that the coal in question is not a portion of the great old coal formation, but of the same age as the coal in the Permian rocks of Russia, and that the strata have been inverted where our author examined them, a phænomenon easily understood in a region so highly metamorphosed as Newfoundland, and where rocks of the age of the Magnesian Limestone may have been locally placed beneath true carboniferous strata. It would be wrong, however, to attempt more than mere suggestions from any evidence which has yet been brought before us, since Mr. Jukes has found no traces of organic remains even in these uppermost deposits of Newfoundland. In truth, our associate has evidently had to grapple with some of the most ambiguous rock-masses of North America, in a country obscured by moss and vegetation, as yet impassable to the casual traveller, and the coasts of which are of very difficult access. He deserves, therefore, so much the more our thanks for having pioneered the way under many difficulties, and for giving us this outline reconnaissance of the geological structure of a colony, to become well acquainted with which will require elaborate surveys, conducted by those who have previously made themselves masters of the keystones of succession in the adjacent continent. When, therefore, the true geological equivalents of

* See also some very interesting observations on the structure of Newfoundland in Sir R. Bonnycastle's 'Newfoundland in 1842,' vol. i. p. 179.

Canada and Nova Scotia shall have been thoroughly established by the researches of Mr. Logan, and placed in exact relation to the well-developed rocks of the United States, the obscurity which shrouds Newfoundland may be dispelled*.

Secondary and Tertiary Rocks, and superficial deposits of North America.—In my Address of last year I had no hesitation in predicting, that geologists would reap great instruction from the visit of Mr. Lyell to the United States. The earlier sketches which he sent to us, including accounts of the Palæozoic rocks, might be taken, indeed, as some earnest of what was to follow, and as we are well acquainted with his powers of generalizing and habits of faithful research, we could not well over-estimate the amount of production at his hands. The documents which he has laid before you have fully justified our anticipations. One of his memoirs, on the Tertiary formations and their connexion with the chalk in Virginia, North and South Carolina, and other parts of the United States, has a very important bearing in showing the amount of agreement of those deposits with the strata of similar age in Europe. Noticing with due approbation the works of Professors W. B. and H. D. Rogers and Mr. Conrad, on the Tertiary rocks of Virginia, he shows, that certain deposits above the chalk are of true Eocene character, and never contain Secondary fossils or any forms intermediate between the newer Secondary and older Tertiary types. These Eocene beds are surmounted by rich shelly deposits, the contents of which bear a great generic resemblance to those of the Suffolk crag and the Faluns of Touraine, and are therefore referable to the Miocene epoch.

In North Carolina, black shales, first described by Mr. Hodge, are shown to be of the cretaceous age by containing Belemnites, Exogyræ, Gryphææ and Ostraeæ, a few of the species being well known in Europe, and found by myself in the distant parts of Russia. This cretaceous deposit is covered by a peculiar calca-

* I regret that I accidentally omitted to call attention in my last Address to a short memoir, read during the preceding session by Mr. Henwood, upon the Silurian Rocks of Lockport near Niagara. Having long been assiduously occupied in his native county Cornwall in studying the mineralization of rocks, Mr. Henwood is, I understand, about to publish a work on the metalliferous deposits of Cornwall and Devon.

reous rock, the Wilmington limestone and conglomerate, which had been termed Upper Secondary, and supposed to indicate a passage from the Secondary to the Tertiary periods, but in which Mr. Lyell could detect no organic remains to support that opinion, the only determinable species being of the Eocene age. Again, in South Carolina, on the Santee river, a white limestone occurs, which lithologically so resembles one of the upper members of the cretaceous deposits of New Jersey, that even Mr. Lyell at a first view, had no doubt it was a portion of the same formation: on examination, however, of the fossils, it proved also to belong to the tertiary series. This lithological resemblance had erroneously led to the admission of several well-known tertiary fossils into the Cretaceous system of America, an error which Mr. Lyell has removed. This correction is valuable, and, though it tends to negative a hope which I once entertained, founded upon what my friend Professor Sedgwick and myself believed to be very good evidence on the flanks of the Austrian Alps, that beds of passage would be discovered between the Cretaceous and Eocene epochs, I am bound to say that the transatlantic researches of Mr. Lyell go far towards the establishment of an extensive, though I still incline to consider not a general break between those periods; for he prudently admits, that evidences differing from those he obtained, may be found in the Southern states bordering the Atlantic, of which he explored but a small part. Referring you to the abstracts of his memoirs, and knowing that you will soon have from him more complete details, I will not occupy your time in attempting to give what would convey an imperfect idea of the succession of the widely spread tertiary deposits, which occupy nearly all the portion of Georgia and South Carolina between the mountains and the Atlantic. Illustrating the observation of Mr. Maclure, that the first falls of the Savannah and other rivers of this region are at the junction of the tertiary strata with granitic and hypogene rocks, Mr. Lyell shows, that at some points, as near Augusta in Georgia, where the former have been made up of the detritus of the primary rock, they have the aspect of gneiss; a fact quite analogous to that which I had the pleasure of observing in his company many years ago in Central France, where the oldest tertiary and freshwater beds repose at once upon the granites of the Puy en Velay. After a laborious comparison of a profusion of fos-

sil shells from the American strata, in the determination of which he acknowledges the liberal assistance and co-operation of Mr. Conrad, Mr. Lyell sees fresh and strong grounds for adhering to his former views respecting the value of testing the age of tertiary strata, by the smaller or greater per-centage of existing species which are to be detected in each deposit; for he finds the same proportions which had been established between the fossils of European basins and the living mollusca of adjacent bays, to hold good in the Eocene and Miocene deposits of the United States, when compared with the existing fauna on their shores.

In supplying us with new evidences of the recession of the Falls of Niagara, which he described last year, Mr. Lyell has also given us a sketch of the ridges, elevated beaches, inland cliffs and boulder formations of the Canadian lakes and valley of St. Lawrence. After referring to the researches of Capt. Bayfield at and around Montreal and Quebec, he enters upon a general survey of the great boulder formations on the borders of the Lakes Erie and Ontario; and states that in the valley of the St. Lawrence, as far down as Quebec, marine shells of arctic character have been found associated with coarse detritus. As some of this shelly and boulder deposit lies at about 500 feet above the sea, and as Lake Ontario is at a much lower level, it is inferred that the sea in which the drift was formed extended far over the territory bordering that lake. That the same sea extended as far south as 44°, 30′ north latitude, is proved by the presence on the shores of Lake Champlain, of marine shells; which, in their Arctic forms and close agreement with those of Uddevalla in Sweden, formerly described by himself, are supposed to imply, like those of the St. Lawrence, the former prevalence of a cold climate when the drift originated. In regard to the far transported boulders, they have in one locality (Beauport) been found both above and below the sea-shells.

The parallel and continuous ridges of sand and gravel, which by Mr. Roy and other authors had been considered to be the shores of an enormous lake, successively let off, are said to rest on clay of the boulder formation, and yet to be occasionally capped by blocks of granite and other hard rocks. Comparing them with the *Osars* of Sweden, and stating, from the evidence of Mr. Whittlesey, that their base-lines are not so horizontal as had been supposed, Mr.

Lyell inclines to the belief, though no shells have been found in them, that they were all formed under water, and probably beneath the sea, as banks or bars of sand, admitting at the same time that some of the less elevated ridges may be of lacustrine origin.

The last observation seems to open out the whole question of whether vast freshwater lakes, extending far beyond the area of those which now exist, may not, at one period, have covered the interior of America.

This opinion has been long entertained by our associate, Mr. Featherstonhaugh, who, in his researches eight years ago, amid the western and untravelled tracts, where the sources of the great rivers are separated from each other by very slight elevations, discovered fluviatile and lacustrine shells, wherever excavations existed or pits had been sunk, and at great distances from the courses of the present streams. I have the more pleasure in making this allusion to the geological labours of Mr. Featherstonhaugh, because he near fifteen years ago pointed out some of the chief phænomena connected with the retrocession of the Falls of Niagara. He was among the first persons, subsequent to his survey of large tracts of the far-west country of Arkansas, to assist in the introduction into the United States of an acquaintance with the most modern school of English geology; and who, after popularizing the subject by public addresses in 1828 and 1829, urged upon the government of that country that geologists should always accompany geographical surveyors *.

The view adopted by Mr. Roy, Mr. Featherstonhaugh and others, of the former presence of inland lakes in North America larger than those which now prevail, has recently been sustained by the Rev. Mr. Schoolcraft, an American geographer, in a memoir which he read before the Geological Section of the British Association at Manchester. This author, who has passed nearly twenty years of his life in their vicinity, believes that the former great lakes have been lowered by ancient dislocations. As examples of the bottoms and edges of these former sheets of water, he adduces large belts and tracts of sandy plains, which, from their scanty vegetation and undulated surfaces, have all the appearance of recent desiccation; and as proofs of the water having stood at various levels, he

* See Monthly American Journal of Geology, 1831, by Mr. Featherstonhaugh.

states, that it has left marks of erosion on the mural faces of the harder rocks. But the most original part of this communication, and which may indeed serve to explain the origin of some of the ridges respecting whose origin Mr. Lyell differs from the writers before alluded to, is the actual production of sand-storms by causes associated with these lakes. Indicating some of the most extensive energies of this nature proceeding from Lake Superior, and the powerful action of storms upon sandstone and grauwacke rocks, Mr. Schoolcraft is of opinion, that by a union of powerful currents and furious gales, dunes have been formed which rise to 300 feet above the water. The sand, being first worked up in great bars, has since been transported by the wind over wide tracts, which are thus rendered sterile; stagnant pools are formed in adjacent depressions, once highly productive, and prostrated and buried trees are there associated with freshwater shells; and thus by actual causes, formations of considerable thickness are accumulated. Geologists have long been aware, that wind has been an agent in heaping up some of the deposits whose origin they endeavour to explain, and very striking examples of this operation were adduced by Lieut. (now Capt.) Nelson, R.E., in his account of the modern shelly and sandy limestone of the Bermudas. As no one, indeed, has a better acquaintance with this class of phænomena than Mr. Lyell, it is enough for me to have attracted his notice to the vivid descriptions of Mr. Schoolcraft, which may, I think, aid in explaining some of the superficial appearances in the lake country of North America.

Let us return, however, to the memoirs of Mr. Lyell. Reviewing the series of changes which have taken place in the Canadian and Lake region, Mr. Lyell conceives, that after an early period of emergence, during which lines of escarpment and valleys of denudation were excavated in solid rocks, the surface of the country was submerged, and the cavities filled with the marine boulder formation; and that during the last elevation of the land, the parallel sand ridges were produced, the boulder formation partially denuded, and the different lakes probably formed in succession, leaving a partial sea channel, which, contracting first into an estuary, was eventually converted into the river Niagara. Reaching this point in his order of events, our author succeeds most happily in developing his views concerning the retrocession of the falls of this river; bringing for-

ward arguments to show that during the re-emergence of the land from the sea, a succession of falls must first have been established near Queenstown. The first or uppermost fall, he argues, must have been of moderate height, when the land was sufficiently raised to wear away the Niagara shale, and undermine the incumbent limestone, which is of slight thickness at its termination near Queenstown. This upper fall having thus cut its way backwards, while the remainder of the escarpment was still protected from denudation by submergence, the second fall would next display itself on a further upheaval of the land, the river being thrown over a lower ledge of hard limestone ; finally the land continuing to rise, a third cataract would be caused over the hard quartzose sandstone, which rests on the soft red marl at Lewistown. These several falls would, at first, each recede farther back than the one immediately below it, their distance being greater or less in proportion to the slow or rapid rate at which the land emerged, but they would all at length be united into one fall, the uppermost limestone becoming thicker in its prolongation up the river, and thus retarding the retrogression of the highest cataract, while the two lower falls would continue to recede at an undiminished pace, until each had in its turn overtaken the uppermost.

In describing the coast sections of Massachussets, and in transferring our attention to the interior of Kentucky—localities already rendered classic by American geologists and palæontologists—Mr. Lyell has placed before us a clear view of other leading points of the changes which that great continent has undergone.

The tertiary deposit at Martha's Vineyard, on the coast of Massachussets, had, indeed, been described by Professor Hitchcock, who seeing the highly-inclined position of the beds, the great variety of structure as well as colour of the strata, and the obscure casts of shells which they contain, was much impressed with their apparent similarity to the Lower Tertiary beds, or Plastic and London clay of the Isle of Wight described by Mr. Webster. By a careful examination however of these strata, and by collecting a larger and more varied suite of organic remains than was known to Professor Hitchcock, Mr. Lyell has come to the conclusion, that so far from being of the Eocene age, this formation is at most of no higher antiquity than the Miocene. This result has been obtained by finding the teeth of several specimens of fishes which belong to species

obtained by Mr. Lyell in the Miocene "Faluns" of Touraine, and determined by Agassiz; together with vertebræ, referred by Mr. Owen to two species of whale, the teeth of a seal, and the skull of a walrus; an association which cannot fail to convince geologists that the materials of this island, off the coast of New England, were accumulated at no very distant geological epoch. The high inclination of these party-coloured sands, clay and conglomerates, and the curvatures which some of them have undergone, probably through great lateral pressure, are clear proofs that they have been powerfully upheaved and dislocated; whilst the gravel and boulder formation which covers their edges horizontally, compels us to conclude, that the disturbed beds were submerged during the boulder period, and subsequently elevated to the position in which we now see them.

The presence at Big Bone Lick, on the Ohio, in Kentucky, of great quantities of bones of buffaloes near the spot where salt sources issue through marshy lands, and the existence of the beaten tracks by which these animals approached this spot, render it highly probable that they were allured thither during certain seasons in extraordinary numbers, and that many of them were engulfed and destroyed in the marshy ground.

Mr. Lyell endeavours to show that what occurred within the historic æra to the buffalo, in all probability occurred also to the extinct mammals, whose bones are found in the subjacent clay and marsh to a depth of twenty-five feet, and are associated with modern fluviatile, terrestrial and lacustrine shells, showing that floods of the Ohio have drifted and re-arranged buffalo bones at higher levels than the comparatively ancient marsh. Mr. Lyell suggests, that no great physical revolution of the surface has taken place since the Mastodons died and were buried on the spot, and at a period not very remote from that in which we live. All these remains of extinct quadrupeds, including a horse, which from the incurvated form of its teeth Professor Owen believes to have been of a different species from that which is now living, are said to have existed, as far as the author can judge, all over North America*, at a later period than the deposit of the great boulder drift when the continent was submerged beneath the sea which contained shells of modern species.

* Has any comparison been yet made between the teeth of the American and the European fossil horses?

In connexion with this subject, allusion is made to the observations in South America, of Sir W. Parish and Mr. Darwin; who found that the great Megatheroid quadrupeds lived at a very modern geological period.

The same conclusion respecting the relative age of these fossil quadrupeds and the recent molluscous fauna, is fully substantiated by a clear section and an interesting memoir by Mr. Hamilton Couper of Georgia, recently read before this Society. This author acquaints us, that a shelly post-pliocene deposit, which extends far along the coast, and embraces exclusively marine shells of existing species, is covered by a swampy accumulation, in which the tusks of mammoth and mastodon, often in excellent condition and little abraded, are grouped with the remains of the megatherium, horse, &c. All this indicates a very tranquil deposit, a slow and gradual emersion of the bottom of the sea, and a long-continued elevation of the land during the period of those great mammals which have since passed away and given place to man and the present races.

In bringing before us such a number of clear proofs of successive oscillations of the continent of America, drawn from his own observations and those of other authors, and in generalizing on them with his usual skill, Mr. Lyell further deduces a very important corollary from the Arctic character of the shells in the most recent marine or boulder formation of the northern part of the American continent. For, as there can exist no doubt, that whenever and wherever these shells were deposited, whether at Uddevalla in Sweden, near Archangel in Russia, in Great Britain or in America as far south even as Lake Champlain, a very cold climate must have prevailed; and as such submarine accumulations were elevated and formed land before the great mammals in question appeared; so it is manifest, as Mr. Lyell remarks, that these creatures could not have been destroyed by the same cold as that which gave rise to the Arctic shells, and with them to the correlative phænomenon of the transport of great boulders and the scratching and scorings of rocks. This clear reasoning appears to me to be an unanswerable refutation of a leading feature of the glacial theory as propounded in its widest sense. At the same time it must be admitted, that the surface of Great Britain does not offer the same neat division between a former submarine state and beds containing the remains of extinct quad-

rupeds, as the continent of America. In some cases, it is true, as at Market Weighton, described by Mr. W. Vernon Harcourt, there are accumulations of bones which lay in fine shelly clay, with gravel below and gravel above the clay, indicating changes from terrestrial and freshwater to submarine conditions. The Brighton breccia of Dr. Mantell is a fine example of a thick detrital mass, of whose grandeur, and of the powerful agents by which it was heaped up, any one who looks at its composition and at the extraordinary erosion of the surface of the chalk on which it rests, will be convinced; and the bones of elephants are impacted in the very heart of this mass.

Nay, nearly the whole of the cliffs of the eastern shores of England, and large tracts in Norfolk and Holderness in Yorkshire, exhibit, as you know, boulder and detrital accumulations of very tumultuary characters, in which the remains of these great mammals are entombed, sometimes, indeed, mixed up with broken fragments of the same species of shells which in America, it would appear, lie always beneath such bone deposits.

Seeing, therefore, these great differences in the character of the evidence, to what other conclusion can we come, than that the destruction of these great animals commenced at earlier periods in some regions than in others; and that, whilst in America a gradual and steady elevation of the land has preserved records of tracts, which, never since submerged, have been inhabited by successive races of quadrupeds, other countries have been affected from earlier periods by unequal and perhaps more intense oscillations, by which the relations of these animals to submarine and terrestrial conditions have been rendered much more obscure? In a word, the surface of the earth exhibits, in some of its last phases, numberless proofs that no simultaneous general destruction of any such lost races can have taken place; but that each great region, when studied in itself, presents, in the extended sense of the word, local phænomena of accumulation, destruction and renewal.

South America.

This year is marked by a great accession to our acquaintance with South America, by the appearance of the splendidly illustrated work of M. Alcide d'Orbigny, published at the expense of

the French government, and for which geologists have been long waiting with impatience. During eight years of research, this gifted naturalist successively examined the coasts of Brazil, the Republic of Uruguay, the Argentine Republic from the frontiers of Paraguay to Patagonia, the coasts of Chili, Peru and Bolivia; and by a long residence in the last-named country he was enabled to survey, in many directions, a large region from the coast to the interior. The details of his labours form a first part of the work, illustrated by many sections and by one of most beautifully coloured geological maps which ever fell under my observation. In his general observations M. d'Orbigny remarks, that his own observations extend from 12° to 42° south latitude, and from 45° to 80° longitude west of Paris; a surface comprised between the coast of the Atlantic Ocean in Patagonia to Lima on the Pacific; whilst, by collecting the observations of other travellers and examining fossils from more distant localities, his general views may be said to apply to all the vast continent between Colombia on the north and the Straits of Magellan! This author reviews in chronological order the different rocks, and indicates each change which they have undergone, describing the granitic, porphyritic and trachytic masses in relation to their extension, composition and elevatory agency. He then considers in an ascending order of date the sedimentary deposits, which he classifies as *Gneissic* or Primary, Silurian, Devonian, Triassic, Cretaceous, Tertiary and Diluvial or Detrital; showing the dislocations which they have undergone at successive epochs, and the causes of these disturbances.

After an enumeration of all the facts, M. d'Orbigny, under the head of conclusions, sketches out all the great revolutions of which South America has been the scene; a subject on which he seems to display much vigour of thought, but which I cannot now attempt to analyse, without doing injustice to him, not having, in truth, had time to study his work. One only of his inferences I will advert to, as being clearly established by the order of the evidences; viz. that, as the increment of fresh matter has successively taken place from east to west, so the ancient beds of the sea have been heaved up successively on lines trending from north to south, and to the west of that primary, or original nucleus on the Brazilian shores.

Eastern Countries.

Hindostan, Affghanistan and China.—Long as Hindostan has been attached to the British Empire, vast lacunæ remain to be filled up before a general geological map of this peninsula can be published; and yet, in no part of the earth over which British rule extends, is an adequate acquaintance of the subsoil more required. Viewing it as the great centre of civilization of the East, I should hail the day when its governors, employing competent geologists, shall direct a comprehensive inquiry to be made into the whole of its mineral structure, the result of which must prove to be of the highest national value. Let me not, however, do injustice to the able men who have, from time to time, thrown light on this great subject; for in Cautley and Falconer we have recognized geologists whose researches in the northern parts have claimed our highest rewards; whilst Christie, Franklin, Sykes, Malcolmson, Grant and others, have been arduous and successful explorers of the central and southern tracts. Botanical science, warmly fostered by the Indian government, at home and in the East, has flourished under the researches of Wallich and of Royle; and much indeed even in geological inquiry has been accomplished by the latter, who is about to give us other proofs of his geological powers in a memoir on the Tin Mines of Tenasserim. Rejoicing in such progress, I should, however, be better satisfied if a little more public encouragement were extended to our science, and that systematic geological surveys were patronized. It was, therefore most gratifying to me to receive the first volumes of the Calcutta Journal of Natural History, instituted by Dr. M'Clelland; because it is evident, that a work so ably conducted, and acting upon the intelligent classes in the metropolis of our Asiatic empire, must rouse the Indian government to combine the desultory efforts of a few geologists, who, to their great praise, have acquired their knowledge by their own labours, supported chiefly by the exertions of the lamented Mr. Prinsep*. The examples of the governments of the United States and of Canada may well be taken as models; and the truly valuable results which will follow from them, must fully satisfy those even who look to science only when it can be brought into useful operation.

* See also the Madras Scientific Journal.

I may here be allowed to express a hope, that our late occupation of Affghanistan, the travels of our envoys, and the marches of our gallant troops through gorges of such surpassing grandeur, have not been made without obtaining some gleanings of the structure of a part of the globe which we are not likely to be able soon to look upon again. Alas! these wars, with all their crowning glory, have deprived us of one on whom we might have depended for some recital of the natural history of those inhospitable defiles. When the adventurous Burnes explained to us, a few years back, within these walls the outlines of the structure of the wild countries of Bokhara, he taught us what we might expect from him, when he returned from the extensive missions into the lands beyond the Indus, to which the services of his country called him. Cut off in the midst of his brilliant career, and falling under the daggers of those in whom he placed implicit confidence, we have lost in him, if not the tutored geologist, at least the vivid delineator of natural phænomena, whose memory will ever be held dear to those who had the happiness to know him. Let us hope, however, that some officers of the gallant army which has so nobly avenged the death of Burnes and our other slaughtered countrymen, may be able to give us some record of the structure of that diversified region. But if we should be disappointed in this wish, to China I trust we may turn with well-founded confidence, that so vast a region may not be laid open to British enterprise without bringing to us some accession of natural knowledge. Already, indeed, we learn that the quays of Nankin are stored with the finest native coal (as if stationed there to supply our invading steam-vessels), whilst from our former casual intercourse with the mouths of the southern rivers, we knew that tertiary deposits occur in their vicinity. We have now to ascertain whether the coal of Nankin is derived from a central ridge in that wide country, or whether, through the innumerable canals by which it is intersected, the mineral is transported from the Pekin or northern coalfield, to which I last year directed your notice. In short, by acquiring (that which is indispensable for a people like ourselves, whose commercial and maritime advancement depends so essentially upon the application of steam power,) a thorough acquaintance with the carboniferous sites in China, we shall at the same time obtain a general insight into the physical and geo-

logical relations of her rocks. I would even suggest, that agents, possessing sufficient knowledge of coal-fields and mining wealth, should be attached to those permanent stations which are to be occupied by our forces; whence, if a friendly spirit of intercourse is continued, excursions could be made into the interior. Thanks to the diffusion of knowledge, our rulers can now have no difficulty in procuring much useful geological information, even by directing their own officers to make the inquiries within their reach; and if consuls cannot be found, who to a familiarity with statistics add the powers of scientific research, it is at all events well known, that our highly instructed corps of Royal Engineers contains within it several good geologists. Let therefore British statesmen encourage our science; and, casting their eyes around our vast colonies, apply to them some measure of that geological research which they are so judiciously and liberally patronizing in our own islands.

From these anticipations of the exploration of China, we may turn with pleasure to the recent advances which have been made in Hindostan. Notwithstanding all previous researches, a great portion of the peninsula was believed to be slightly interesting to palæontologists, and to contain very few tracts occupied by secondary strata, as interesting as those of the Run of Cutch described by Captain Grant. This opinion has, it appears, been much over-stated; for under the modest announcement of "a collection of fossils discovered by the writer in rocks in Southern India," Mr. Kaye has recently made known to us the presence of considerable masses of limestone near Pondicherry charged with Nautili, Ammonites, Baculites, and Hamites, with numerous genera of conchifers and mollusks, as well as with remains of Polyparia, Echinidæ, and Ichthyolites. Judging from this beautiful collection, which was exhibited at our rooms, there can be no doubt that the fossils belong to the Cretaceous system, of which we have hitherto had no account in southern India; whilst other remains obtained from the neighbourhood of Trichinopoly and Verdachellum may possibly belong to intermediate and younger deposits, and thus a strong additional incentive is supplied to prosecute researches in Southern India, by the discovery of singularly well-preserved chalk fossils, where their existence had never been suspected.

Lt. Baird Smith, E.I.C., has furnished us with a faithful record of certain boring operations at Fort William; curious and instructive in showing the varying nature of the deposits which have for ages been accumulated to form the great Gangetic delta. The lower parts 350 to 480 feet below the surface, were found to consist of rolled pebbles and gravel of crystalline rocks, very analogous to those described by Capt. Cautley at the base of the Himalaya range, whilst the overlying beds were composed of clay and sand, including some hard detritus, and much of the peculiar substance termed Kunkur, and the uppermost strata contained portions of peat and fragments of trees.

Another short memoir on India, by the Rev. R. Everest, is upon the high temperature of wells in the neighbourhood of Delhi. Giving tables of the temperature of numerous wells around three different localities, the most remote being about ninety miles from Delhi, he finds in all a sensible increase of warmth from the surface downwards. The author endeavours to explain the higher temperature of these wells as compared with those of Sincapore, by supposing, that in this sandy tract, entirely devoid of rivers, rivulets, or even springs, the water is exclusively derived from the hot south-west monsoon, which, blowing nearly from the equator, transports and lodges a vast quantity of aqueous vapour having a temperature of 77° to 81°; and as little or no rain falls in the cooler seasons, this fact alone would, he supposes, account both for the high temperature of the surface and that of the interior. Applying this to geology, Mr. Everest says, "it may be easily conceived, that, when a much greater portion of the globe was covered with water and the evaporating surface was consequently larger, currents of air charged with aqueous vapour prevailed still more and modified the ancient climate, *even in still higher latitudes.*"

Egypt.—Let us now consider what amount of information has recently been laid before us concerning the structure of Egypt. Prefacing his sketch of the geology of that country with a view of the physical features which divide it into productive and sterile tracts, and which are intimately connected with the nature of the rocks, Lieut. Newbold* shows, that the horizontal position of the

* Of the East India Company's Service.

great masses of depository strata affords no traces of dislocation except in Upper Egypt, where inclined beds, fissures, and altered rocks attest the agency of eruptive matter. An account of the hypogene rocks, and of the peculiar "breccia di verde," is followed by a sketch of the great sedimentary masses in ascending order, and these consist of three formations only, viz. a lower sandstone, a marine limestone, and an upper sandstone. On the age of the first of these rocks (much used in statuary by the ancient inhabitants), Mr. Newbold, not having acquired fresh information, simply states that Ehrenberg has referred it to the "Quader Sandstein," whilst the French author, Lefevre, has classed it with the "Keuper," or "Marnes irisées." The next, or the marine limestone, is the well-known building stone of the pyramids, which, from the remains it contains, has, I believe, been classed with the *calcaire grossier*, though the list of fossils given in this memoir points to Cretaceous and Miocene as well as Eocene ages. This limestone is inclined and altered in the proximity of the plutonic rocks. In the upper sandstone, which extends into the Numidian and Libyan deserts, and even to Abyssinia, our author found a few casts of marine shells, but too imperfect to enable him to speculate on the precise age of the tertiary rock. Much interest is attached, however, to this deposit, in consequence of its being the matrix of the trees which constitute the petrified forest of which this Society formerly received specimens from Lord Prudhoe, and of which my noble friend gave me a very clear verbal description, stating that the trunks of the trees were occasionally in a vertical position, their whole aspect conveying to him the idea of their being in the place of their growth. Lieut. Newbold describes the stems as chiefly resembling those of a fallen or prostrated forest, the trees being generally directed to the north-west. On clearing away, however, the sand from one of the few stems which are vertical, he found no traces of an ancient soil, like the dirt-bed of our Portland Cycadeæ, but, on the contrary, the end of the trunk was imbedded in the conglomerate which is associated with the sandstone*.

From the remains in the limestone and sandstone Mr. Newbold infers, that those parts of Egypt around the country of petrified

* Mr. Robert Brown has pronounced these trees to be dicotyledonous.

trees had twice formed the bed of the ocean, and twice been elevated into dry land, and that the trees in question lived in the period between the two submergences. Posterior to those movements of oscillation, which, from the horizontality of the strata, was probably very gradual, the land has undergone additional elevation around the head of the gulf of Suez, and between the Red Sea and the cliffs which skirt its western shores as evidenced by a fringe, in parts about fifty feet high, of calcareous shelly deposits, charged with the remains of Radiaria, Testacea, and Corals which now inhabit the Red Sea.

However comparatively recent this elevation may be, Mr. Newbold contends, that the great dissimilarity of the faunas of the Red Sea and the Mediterranean, renders it probable, that there was an ancient barrier of separation, and that therefore the isthmus of Suez has not been formed in a recent æra. On this point, however, we have gained still more definite information by the researches of our Curator, Mr. E. Forbes, and to these I have already alluded.

For an account of the various intrusive rocks, and for much information respecting the alluvial accumulations, including the mud of the Nile and the changes of the Delta of that river, as well as of the sand-drifts which have sterilized such large tracts, I must refer you to the Memoir itself, which indicates great assiduity on the part of the author, and who seems to have neglected no sort of information which could be brought to bear upon the illustration of his subject.

After all, it must be allowed that, with the exception of the fossil forest, and the recent elevation of her shores which separated the Mediterranean from the Red Sea, Egypt presents fewer phænomena to interest the geologist than any region of similar range over which researches have extended; for this mass of land seems to have been above the waters during the whole of the ancient periods of which other regions afford such long registers in the contents of the Palæozoic and succeeding deposits.

We have, however, but to advance northwards to the Lycian Taurus, where Mr. E. Forbes has made known to us the elevation to great heights of tertiary marine shells; or north-eastwards to Syria,

where the Dead Sea, as now computed, lies upwards of 1300 feet below the level of the Mediterranean, and we are furnished with the most remarkable proofs of the mighty oscillations to which the surface has been subjected, even in recent epochs. In receding from the Mediterranean to the Dead Sea, the Lake of Tiberias marks the first depression, being 328 feet beneath the sea, and from this lake to the Dead Sea the declination is nearly 1000 feet! A few years back only and we were startled at the announcement, that the level of the Caspian Sea was 300 feet below the Mediterranean; and more accurate measurements have, indeed, reduced the depression to 82 feet; but that any cavity on a portion of the present surface should be 1300 feet beneath the level of the adjacent seas, proves an amount of vibration within a limited area, which is truly astonishing*.

Palæontology.

Ichthyology.—Geologists who have commenced their career since the glacial theory has been in vogue and have read the numerous memoirs and heard the exciting discussions to which it has given rise, are chiefly acquainted with Professor Agassiz as one of its most ingenious expounders. I have now the pleasure to acquaint you that M. Agassiz is once more completely absorbed in his great work on fossil fishes—that work which you so justly honoured, in the year 1835 to 1836, with your Wollaston Donation and Medal. Of his progress in this arduous undertaking, he has recently given substantial proofs, in the description of many ichthyolites of the Old Red Sandstone of Scotland; and, in addition to this, he will shortly publish a series of fossil fishes, exclusively illustrative of the tertiary basins of London and Paris, from which an enormous number of species has been collected.

In reference to the geological researches of my friends and myself in Russia, I must here state, that as it is our one great object to

* See the last discourse of Mr. W. Hamilton, the President of the Royal Geographical Society, who points out this admeasurement as being at length fixed by the admirable trigonometrical survey of Lieut. Symonds, whose calculations of 1311 feet approach very nearly to the still higher estimate of M. Berthou, who, from barometrical observations, placed it at 1332 feet.

place in correct parallel the Palæozoic types of Russia with those of the other parts of Europe, we could not hesitate in referring all our Russian ichthyolites to Professor Agassiz; for whilst it must be acknowledged that Russia contains naturalists of great merit, and that among them M. Pander and Professor Asmus had commenced inquiries into the nature of these fossils, it was obvious that, skilful as they undoubtedly are, they could not, for want of comparisons, afford us the knowledge of which we stood in need. Professor Agassiz, who has at his disposal fossil fishes from all those parts of Europe, the geological structure of which has been well explained, was alone capable of answering the following query; To what extent do the ichthyolites of Russia, which lie in beds superior to the Silurian rocks, and which are surmounted by the Carboniferous limestone, resemble those with which we are so well acquainted in Scotland and England? His reply has indeed been most satisfactory.

So complete, says he, is the identity of about ten species of the Scottish and Russian strata, that the specimens from the two countries may be confounded. Among them the *Holoptychius nobilissimus*, three species of the *Dendrodus* (Owen), *Diplopterus macrocephalus*, are forms which might strike any good observer, as they have been previously published by M. Agassiz; but from the more perfect specimens of other species which we brought from Russia, he has been enabled to recognize the presence in Scotland of the species of a common Russian genus, the *Glyptosteus*, and also of that gigantic genus the *Chelonichthys*, to whose remains I have before directed your attention as having been recognized to be of ichthyic character by Professor Asmus. To this enormous fossil fish, some of whose thoracic bones are as large as the breast-plate of a well-grown warrior, and a single bone of which measured nearly three feet in length, Professor Agassiz has given the name of *Chelonichthys Asmusii*; and he now informs me that he possesses fragments of the same creature from the north of Scotland. The knowledge of this fact will doubtless lead to redoubled activity on the part of Mr. Hugh Miller and those Scottish naturalists who inhabit the shores of the Cromarty and Murray friths, to produce a rival of the Russian giant; a hope which I cannot express without deeply

amenting the death of a most successful explorer of these remains, whose loss geologists have to deplore, in common with every one who could appreciate her range of thought, her accomplishments, and her goodness*.

The results, however, of the examination of the Russian ichthyolites go still further; for, on submitting to the microscope of Professor Owen some teeth similar in outline to those of his genus *Dendrodus*, he discovered in them precisely the same dendridic disposition of the vascular canals as that which led him to establish the genus from Scottish fossils. Nor does the value of this application of the microscope stop here, for Professor Agassiz has informed me, that availing himself of the weapons which Professor Owen had so skilfully wielded, he has commenced a series of researches, not only into the teeth but also into the structure of all the hard enamelled bones of the Russian fossil fishes, by which he will be able to show the same distinction in the other bones of the genera of this class, which Professor Owen has successfully established in relation to the hard parts of the higher order of animals. In such hands, therefore, the microscope has become an instrument of great utility in identifying fragments apparently obscure; and, as it has been applied to the shells of Mollusca, and even to the lowest links in animal life, as well as to fossil plants, the geologist has thus acquired a new and powerful auxiliary. I am here, however, treading on ground now fortunately occupied by the Microscopical Society, the active promoters of which are well entitled to our gratitude.

Ornithichnites.—To American geologists we are indebted for our acquaintance with this new class of phænomena. The existence of the fossil bones of birds of ordinary size had, it is true, been ascertained by Dr. Mantell in the Wealden strata, but great was our astonishment, and I may add our incredulity, when Professor Hitchcock first announced, that in rocks of considerable antiquity (the exact age of which is still uncertain), there existed innumerable impressions in successive layers, which must have been formed by birds, some of them of gigantic size, and to which he boldly assigned the name of "Ornithichnites." Various opinions were entertained, and much scepticism prevailed concerning these impressions; but

* Lady Gordon Cumming.

it is due to Dr. Buckland to state, that he never doubted that the views of Professor Hitchcock were founded on true natural analogies, and he accordingly published this opinion, with illustrative plates, in his Bridgewater Treatise. The recent visit of Mr. Lyell to North America, and a memoir he has read, as well as a communication from Dr. James Deane of Massachusets, have necessarily brought this highly interesting subject again before us; whilst a very remarkable discovery in natural history has at all events almost entirely dispelled scepticism regarding the true *bird-like character* of even the largest of the footsteps, however difficult it may be to imagine the presence of such highly organized creatures at a very early period. The observations of Mr. Lyell completely support the views of Professor Hitchcock as to the littoral nature of the footstep deposit in Connecticut, and that the prints in question were left by birds on the mud and sand of former estuaries, the bottoms of which were gradually submerged, and by the increase of fresh matter were permanently preserved.

Mr. Lyell illustrates the ancient phænomena by reference to impressions which he saw forming at low water on the mud of the sea shore of Georgia by racoons and opossums, and covered by blue sand before the flow of the tide, as well as by the recent footsteps of birds in the red mud of the Bay of Fundy, which if submerged would realize a complete analogy to the fossil footsteps through many successive laminæ of deposit*. He also believes with Professor Hitchcock, that the strata in question had been elevated and tilted since their original deposition, and he connected these movements with the evolution of trappean rocks, which in some places invade the Ornithichnite beds. In regard to the age of these beds no decisive opinion has yet been expressed, though they are referred to one of the older secondary rocks. However this point may be determined, and I will presently allude to it, the great question remained to be settled; how induce us to believe that the largest of these footmarks were made by birds? Is it not unsafe to call in

* A striking explanation of appearances, respecting which we were at first equally incredulous when pointed out on the surface of the Red Sandstone of England as fossil rain-drops, is given by Mr. Lyell in the actual formation of similar markings produced by rain on the mud of the shores of Long Island.

the presence of creatures of such high organization when researches all over the world have taught us that in rocks of far less antiquity no traces of the bone of a bird or mammal have been found? May not the impressions after all be those of some singular Sauroid animal with trifid feet, of which we have no links in existing nature? Looking to such a possible explanation, and reflecting on the striking interference with the opinion heretofore very generally received, that a succession from lower to higher orders of creatures was invariably evidenced in ascending from lower to higher deposits, I candidly confess, that nearly up to the present moment, despite of the clear and faithful descriptions of the facts, I have clung to the idea, that the markings would not eventually be referred to the action of birds. My scruples as a geologist have, however, I confess, been much shaken, if not entirely removed, by a discovery in natural history, which I do not hesitate in characterizing as one of the most remarkable of modern times.

From the examination, in 1839, of a single fragment of a bone brought from New Zealand, Professor Owen, though at first startled by its enormous size, at length pronounced it to belong to a gigantic form of the lowest organized bird, analogous to the diminutive Apteryx of the same island, in which the lungs approach more closely than in any other bird to the structure of those in reptiles. To this monstrous winged animal he assigned the name of *Dinornis*, and many of its bones, in a very perfect condition, having been subsequently found in New Zealand and deposited in the museum of the College of Surgeons, his opinion has been completely confirmed.* When it is known that the tibia of this bird is so huge that the femur of the Irish giant is of pigmy dimensions when compared with it, some conception may be formed of its entire size, which must have far exceeded that of the ostrich†.

Now to apply this discovery to our Ornithichnites, one of the great difficulties which many of us had to overcome was

* The inhabitants of New Zealand believe that the Dinornis was in existence with their progenitors. On this point, however, doubts may still be entertained, as we know that in many uncivilized countries, where the bones of extinct quadrupeds occur, the natives connect them with their ancestors.

† See a most graphic sketch of this monstrous bird and its analogies from the pen of my friend Mr. Broderip, Penny Cyclopædia (*Unau*).

the gigantic size of the largest American footsteps, which measured fifteen inches in length; and it is a most curious fact, that upon placing the fossil cast alongside of the metatarsal bone and tibia of the largest individual of Dinornis, Professor Owen is of opinion, that if the feet of this great tridactyle bird be found, they will, from the usual proportions maintained in such animals, be fully as large as those of the American Ornithichnite. From this moment, then, I am prepared to admit the value of the reasoning of Dr. Hitchcock, and of the original discoverer, Dr. James Deane, who it appears, by the clear and modest paper lately brought before us by Dr. Mantell, was the first person who called the Professor's attention to the phænomenon, expressing then his own belief, from what he saw in existing nature, that the footmarks were made by birds. Let us now hope, therefore, that the last vestiges of doubt may be removed by the discovery of the bones of some fossil Dinornis; and in the meantime let us honour the great moral courage exhibited by Professor Hitchcock, in throwing down his opinions before an incredulous public*.

Still, however, comes the question, what is the age of the rock on which the Ornithichnites have been impressed. Consulting what Mr. Lyell has recently written, we find that he does not decide this point further than by saying, that they were formed between the carboniferous and cretaceous epochs, the only remains hitherto found in the deposit being ichthyolites of the genera Palæoniscus and Catopterus, with some fossil wood. The presence of a Palæoniscus would lead me to suspect that the deposit might be of the age of the Zechstein or Magnesian Limestone; for in Russia, wherever the calcareous matter which represents that rock thins out, vast tracts are occupied by marls, sandstones and conglomerates of red, green and white colours, which form the Permian system, and in these beds Palæonisci occur. If the fossil fishes from both localities be placed in the hands of Professor Agassiz, and a comparison be made of the fossil wood from Russia and North America, the query may be satisfactorily answered. In the meantime I cannot read the descriptions of this American deposit, and carry the Russian types in my recollection, without surmising, that in the sequel the Ornithichnite and

* See Geol. Proceedings, January 1843, Dr. James Deane 'On Ornithoidichites.'

Palæoniscus beds of Connecticut and the gypsiferous rocks of Nova Scotia, distant as they are from each other, will be found to belong to one natural group—the Permian; and if this view be borne out, it follows that a bird analogous to the Dinornis lived at a period when Saurian animals first began to appear upon the surface, and when the last links of primæval or palæozoic life were not obliterated *. In this case the value of the philosophic caution given by Mr. Lyell will be very apparent, viz. that we ought not to infer the non-existence of land animals from the absence of their remains in contemporaneous marine strata †.

Saurians, Cetaceans, &c.—I am not aware that researches of the past year have added much to our acquaintance with new forms of vertebrata in the secondary deposits, though it must not be unrecorded, that our zealous contributor M. Hermann Von Meyer, has added to the list of Saurians of the Muschelkalk a new genus, which he describes under the name of Simosaurus.

In Russia a very curious discovery has been made by Professor Brandt, of which I have been just informed by my friend Count Keyserling. Pallas had spoken of a locality among the cliffs of Taman, in the southern steppes, where remains of whales were found; Rathke had mentioned the head of an animal of which the vertebræ were known, and which he described as approaching to a whale; and more recently Professor Eichwald considered this fossil as belonging to the Dolphins and named it *Xiphias priscus*. Obtaining possession of the specimen for the museum of St. Petersburgh, Professor Brandt worked the head of the colossal creature out of the rock in which it was imbedded, and pronouncing it to belong to a new family of whales, described it under the name of *Cetotherium Rathkii*. This fossil whale forms a new link in the animal kingdom, and is more nearly allied to the herbivorous cetaceans than to the Dolphins. Its position in the geological series is also most remarkable; for the rock in which it occurs contains shells similar to those of the tertiary deposits of the Miocene age, which extend from Volhynia and Podolia to the Crimea and Taman. It is also very remarkable, that along with this herbivorous cetacean the other

* This view has been strengthened by the researches of Mr. Logan, see note, p. 84.

† Geol. Proceedings, vol. iii. p. 796.

organic remains (among which, however, banks of corals occur) have more the character of the inhabitants of a brackish sea than those of the subjacent rocks, whose fauna more resembles that of the Black Sea and the Mediterranean.

These relations are in accordance with modern conditions, and are, indeed, explained by an analogy in our own country, for an acquaintance with which I am indebted to our Curator, Mr. E. Forbes. The lake of Stennis, in the Orkney Islands, celebrated by Sir Walter Scott, has been converted, whether by elevation of the land or other cause, from a saltwater loch into a freshwater and marshy tract, and with this great but gradual change, certain marine genera have continued to live on amid their new associates of land and fresh water, whilst others have perished. That which is taught on a small scale in the Scottish lake has occurred over a vast area in the case of the Caspian Sea; which, in consequence of separation from the Black Sea has passed into a brackish state, and the same hardy and time-serving marine genera as in Scotland have continued to exist in their new abode! The Miocene deposit of Taman, therefore, with its herbivorous cetaceans, brackish and marine shells, is only an example, in an earlier period of the world, of the formation of a true Caspian, the creatures in which necessarily differed from those of the pure marine period which went before them.

MASTODONTOID AND MEGATHERIOID ANIMALS.

For a season our metropolis contained within it a magnificent skeleton of a Mastodontoid quadruped, which, in common with all geologists and palæontologists, I hoped to see permanently established in our national Museum. This gigantic animal was discovered by a persevering Prussian collector, M. Koch, who for some time resided in the United States, and who disinterred it, together with a great profusion of heads, teeth, and numerous bones of similar animals, from amid the alluvia of a tributary of the St. Louis river, where the chief remains had probably been an object of superstitious tradition on the part of the Indian tribes. It does not appear whether the zealous Prussian had any scruples to overcome; but I presume they must have been considerable, if I were to

judge from my own experience in other wild countries. In travelling along the eastern flanks of the Ural Mountains, it was my lot to visit many sites of gold alluvia in which bones of the mammoth and other extinct quadrupeds are found, and for these remains the poor Bashkirs, the original inhabitants of the tract, preserved so deep a veneration, that in freely permitting the search after the true wealth of their country which they were incapable of extracting, their sole appeal to the Russian miners was, "Take from us our gold, but for God's sake leave us our ancestors."

Overcoming, however, all difficulties, M. Koch succeeded in extracting, and afterwards in setting up, the most complete specimen of the species which has ever been seen. Applying to it the provisional name of "Missourium," he exhibited it for some time in the United States, and then brought it with many of the associated bones to London, in the hopes both of having the remains perfectly described and of obtaining for them a price worthy of the British nation.

The arrival of such a collection could not fail to excite the most lively interest and curiosity among our naturalists, and the bones having been attentively examined by many members of this Society, produced a diversity of opinion respecting the generic character of the chief remains. North America had long been a fertile mine of such reliquiæ, and the naturalists of the United States had not been backward in studying and describing them. It is not, therefore, a little remarkable that the same difference of opinion as to the generic and specific identity of the animals that prevailed across the Atlantic, is presented in the Memoirs which have recently been read before us; Dr. Harlan and Mr. Cooper having maintained opinions, with which, to a great extent, Professor Owen concurs, whilst Dr. Grant and M. Koch have supported the views of the late Dr. Godman.

Citing the American authorities on his side of the question, including Dr. Hayes, and enumerating no less than thirteen species of Mastodon and six species of Tetracaulodon, Dr. Grant has made a vigorous effort to vindicate the true generic characters of the Tetracaulodon as founded on the presence of a tusk or tusks in the lower jaw and certain variations in the form of the crowns of the molar teeth.

This view has been sustained by Mr. A. Nasmyth in an elaborate paper "On the Minute Structure of the tusks of extinct Mastodontoid animals." Microscopical examination of portions of the tusks believed to belong to five distinct species, viz. *Mastodon giganteus*, *Tetracaulodon Godmani*, *T. Kochii*, *T. Tapiroides* and the *Missourium*, has also led this author to the same inference as Dr. Grant; and he concludes with the remark, that, if it be established that specific differences positively do exist among all these animals, the value of such microscopic researches is great; but if the five animals are grouped as one, then such mode of observation is of no value in palæontological science.

Professor Owen had previously expressed opinions at variance with those of Drs. Hayes, Godman and Grant and Mr. Nasmyth, and his views have been supported within these walls by my predecessor, Dr. Buckland. Pointing out certain mistakes in the setting up of the Missourium, as exhibited in the Egyptian Hall, he compares the fossil with all forms with which he was acquainted; and, showing that it must have belonged to the Ungulata, he judges that the enormous tusks of the upper jaw constitute it a member of the proboscidian group of pachyderms, and that the molar teeth prove it to be identical with *Tetracaulodon* or *Mastodon giganteus*. He argues that the genus Tetracaulodon was erroneously founded upon dental appearances in the lower jaw of a very young proboscidian, and that Mr. W. Cooper was correct in suggesting that the Tetracaulodon was nothing but the young of the gigantic Mastodon, the tusks of which were lost as the animal advanced in age. A comparison of the whole of M. Koch's collection produced the result in Mr. Owen's mind, that, with the exception of a few bones of the *Elephas primigenius* (Mammoth), all the other remains of proboscidean pachyderms in it belong to the *Mastodon giganteus*. The remains of other animals found by M. Koch are referred by the Hunterian Professor to *Lophiodon*, *Mylodon Harlani*, *Bos*, *Cervus*, &c.; and in respect to the *Mastodon giganteus* he expresses his conviction that it had two lower tusks originally in both sexes, and retained the right lower tusk only in the adult male. Although unable to form a correct judgement on the probable structure of those extinct quadrupeds, I may call your attention to a recent work of Mr. Kaup, whose striking discovery of the Deinotherium

is familiar to you, and who now seems to advocate, from perfectly independent sources of evidence, the same views as Professor Owen concerning the osteology and generic characters of the Mastodon founded upon the comparison of a series of bones and teeth belonging to the *Mastodon longirostris*, more numerous and complete than even those of the *Mastodon giganteus*.

Mylodon.—One of the most brilliant, and, I venture to say, not the least durable of the researches in palæontology, remains to be mentioned in the description of the *Mylodon robustus*, a new species of gigantic edentate animal, accompanied by observations on the affinities and habits of all Megatherioid animals. After a sketch of the labours of Cuvier, who first described the huge Megatherium and pointed out its analogy to the family of Sloths and Armadillos, of the succeeding writings of Jefferson and Harlan upon the genus Megalonyx, of Dr. Lund on the Cœlodon and Sphenodon of Brazil, and of his own researches which established the Mylodon and Scelidotherium, Professor Owen proceeds to describe the megatherioid animal which he has named *Mylodon robustus*.

Of the purely anatomical descriptions, it is not my province to speak, and referring you to the work in which, through the enlightened munificence of the College of Surgeons, all the necessary illustrations have appeared, I pass to the generalizations, and learn that the Mylodon, in common with the Megatherium and Megalonyx, are genera of the family of *Gravigrada*, as distinguished from the *Tardigrada* in the order *Bruta*.

Professor Owen then proceeds to a comparison of the anatomy of the Mylodon with that of all analogous creatures, and after an able analysis, he satisfies himself, and also, I am persuaded, every one who has followed his close reasoning, that he has at length ascertained the true habits and food of this family of mammifers. From their dentition, it is inferred that the Megatherium and Mylodon must have been phyllophagous, or leaf-eating animals; whilst, from their short necks, the very opposite extreme to the camelopard, they never could have reached the tops of even the lowest trees. Cuvier, on the contrary, suggested that they were fossorial, or digging animals; and we all recollect the animated manner in which Dr. Buckland attracted us, whilst he described the Megatherium as a huge beast, which, resting upon three legs, employed one of its

long fore-hands in grubbing up whole fields of esculent roots; a habit which procured for it the significant popular name of "Old Scratch."

Dr. Lund, a Danish naturalist, had considered the Megatherium to be a scansorial or climbing animal; in short, a gigantic Sloth. After a multitude of comparisons, Professor Owen rejects the explanation of all his predecessors. He shows that the monstrous dimensions of the pelvis and sacrum, and the colossal and heavy hinder legs, could never have been designed, either to support an animal which simply scratched the earth for food, or one which fed by climbing into lofty trees, like the diminutive Sloth; and he further cites the structure of every analogous creature, either of burrowing or climbing habits, to prove, that in all such the hinder legs are comparatively light. What then was the method by which these extraordinary monsters obtained their great supplies of food? The osteology of the fore-arm has, it appears, afforded answers which are valuable, chiefly for their negation of erroneous conjectures, such as that the animal was an ant-eater, rather than for the habits which it directly elicits. It is, therefore, to the organization of the hinder limbs that Professor Owen mainly appeals to ascertain the functions of the forefeet and the general habits of the Mylodon.

Arguing that the enormous pelvis must have been the centre whence muscular masses of unwonted force diverged to act upon the trunk, tail and hind-legs, the latter, it is supposed, formed with the tail a tripod on which the animal sat. Professor Owen supposes that the animal first cleared away the earth from the roots with its digging instruments, and that then seated on its hinder extremities, which with the tail are conjectured to have formed a tripod, and aided by the extraordinary long heel as with a lever, it grasped the trunk of the tree with its forelegs. Heaving to and fro the stateliest trees of primæval forests, and wrenching them from their hold, he at length prostrated them by his side, and then regaled himself for several days on their choicest leaves and branches, which till then had been far beyond reach. After showing that from the natural inversion of the hind-feet the Mylodon approached to the scansorial animals, and thence inferring that it might have had climbing powers necessarily much limited by the other

parts of its frame, Professor Owen states, that the inversion of the soles of the feet is least conspicuous in the Megatherium, whose bulk and strength would be adequate to the prostration of trees too large for the efforts of the Mylodon, Megalonyx and Scelidotherium. The Megatherium, in short, was the mighty tree-drawer, and had therefore no need of the adventitious aid of any climbing apparatus. Allow me to add, that, amongst other reasonings, those which lead to conclusions that one class of megatherioid animals was furnished with a hairy coating (like the Mylodon), whilst another, like the great Megatherium, was devoid of it, as evidenced by slight modifications of the bony structure of the hind-feet, appear to me to be not the least original and interesting.

Wholly incapable, as I am, to do justice to this masterly inquiry by the necessarily brief allusion which is imposed upon me by the nature of this discourse, I shall best execute my task in quoting the words with which Professor Owen sums up his reasoning.

" On the Newtonian rule, therefore, this theory has the best claim to acceptance ; it is, moreover, strictly in accordance with, as it has been suggested by, the ascertained anatomy of the very remarkable extinct animals, whose business in a former world it professes to explain. And the results of the foregoing examination, comparisons and reasonings on the fossils proposed to be described, may be summed up as follows. All the characteristics which exist in the skeleton of the Mylodon and Megatherium, conduce and concur to the production of the forces requisite for uprooting and prostrating trees; of which characteristics, if *any one were wanting, the effect could not be produced*: this, therefore, and no other mode of obtaining food, is the condition of the sum of such characteristics, and of the concourse of so great forces in one and the same animal."

This, Gentlemen, is the true Cuvierian style, in which, as in numberless parts of his works, Professor Owen has continued to breathe out the very spirit of the founder of palæontological science.

It is by such labours that geology is steadily gaining a higher place among the sciences. Comparative anatomy has truly been our steadiest auxiliary, and well may we do honour to those who impart to us such truthful records; for, whilst the histories of the earlier beings of our own race are shrouded in obscurity, whilst the first chronicles of ancient Rome and Greece are now admitted

to be exaggerated, and often even fabulous, we turn back the leaves of far more antique lore; and, not trusting to perishing inscriptions, mutilated by successive conquerors, and assuming a hundred meanings under the eyes of doubting antiquaries, we appeal only to the proofs in nature's book, and find that their reading is pregnant with evidences which must be true, because they are founded on unerring general laws.

In concluding this Address, I can assure you, Gentlemen, that, although not prepared without some labour, its composition has afforded me both gratification and instruction. Had I not felt a strong obligation to fulfil my duty, I should necessarily have been absorbed in the preparation of the work upon Russia to which I have alluded, and could not therefore have been imbued with an adequate sense of the vast progress which our science has recently made in all quarters of the globe.

The chief aim of this Society has been to gather sound data for classification; and, following out this principle, I have endeavoured to show, how the order of succession established in our own isles, is now extended eastwards to the confines of Asia, and westwards to the back-woods of America. From such researches, and by contributions from our widely spread colonies, we have at length reached nearly all the great terms of general comparison.

Besides ascertaining where the great masses of combustible matter lie, we can now affirm, that during the earliest period of life, conditions prevailed, indicating a prevalence over enormous spaces —if not almost universally—of the same climate, involving a very wide diffusion of similar inhabitants of the ocean. We have learned, that in the earliest of these stages of animal life, no vestige of the vertebrata has yet been found, whilst in the succeeding epochs of the Palæozoic age singular fishes appear, which, in proportion to their antiquity, are more removed from all modern analogies. In each of these early and long-continued periods, the shells preserving on the whole a community of character, differ from each other in each division—and in that later formation, where a very few only of the same types are visible, they are linked on to a new class of beings, the first created of those Saurians, whose existence is prolonged throughout the whole Secondary period; whilst we have this year seen reason to admit,

that even birds (some of them of gigantic size) may have been the cotemporaries of the first great lizards. With the close of the Palæozoic æra we have also observed a gradual change in the plants of the older lands, and that the rank and tropical vegetation of the Carboniferous epoch is succeeded by a peculiar flora. In the next, or Triassic period, we have another flora, whilst new forms of fishes and mollusks indicate an approach to that period when the seas were tenanted by Belemnites and Ammonites, marking so broadly these secondary deposits with which British geologists have long been familiar, and which, commencing with the Lias, terminate with the Chalk. And lastly, from the dawn of existing races, we ascend through successive deposits gradually becoming more analogous to those of the present day, until at length we reach the bottoms of oceans so recently desiccated, that their shelly remains are undistinguishable from those now associated with Man, the last created in this long chain of animal life in which scarcely a link is wanting!—all bespeaking a perfection and grandeur of design, in contemplating which we are lost in admiration of creative power.

Such results, grand as they are—nothing less in short than the records of creation—are however but a portion of the labours of geologists. They have also struggled to explain the causes of those great revolutions. In some continents, it is true, the pages in the book of nature are, as it were, unruffled; for, by whatever agency effected, it is certain that beds of vast ancient oceans have been so equably elevated and depressed, and again so steadily elevated from beneath the sea, that the continuity of their rocky deposits over areas larger than our kingdoms of Western Europe is unbroken, and their original condition almost entirely preserved. In other regions, on the contrary, the sediments in the sea and the masses of the land have been pierced by numerous outbursts of igneous and gaseous matters, accompanied by violent oscillations and breaks, whereby the chronicles of succession have been sorely defaced, and often rendered more illegible than the most carbonized of the papyri found under the lava of Vesuvius. Nay, so intensely has this metamorphism operated, that obliterating all vestiges of former life, and concealing them from us, we have been sorely puzzled to ascertain by what powerful physical agency such mighty changes can have been accomplished,—changes by which

the strata have been convoluted into forms grotesque as the serpent's coil, inverted in their order, or shivered into party-coloured and crystalline fragments. And yet in these broken and mineralized masses, as another branch of our science teaches, are found the precious ores and the metals most useful to mankind.

Such complicated relations and such changes in original structure call forth the application of the highest powers of physical science; not only involving the agency of that great central heat, to which geologists have willingly referred, but also invoking the aid of agents, some of them still mysterious, by which electricity and magnetism are bound together in the cycle of terrestrial phænomena. To few of us is it given to venture with firm steps into that region; and, though I hope to live to see some of these questions answered, I am well satisfied to have been among you when such solid advances have been made, in deciphering the mutations of the surface of the earth, and in the compilation of a true history of its earlier inhabitants.

Having now, Gentlemen, completed the term of my service, I bid you farewell, as friends in whose society, whilst acquiring knowledge, I have passed the happiest days of my life. Large as our numbers are, and branching out, as our inquiries do, into all the paths of philosophic research, the Geological Society has always held firmly together by a principle of good and high feeling among its active members. I have, indeed, deeply felt the honour of presiding over men who, in the course of a quarter of a century, have demonstrated, that there is no such thing as "*odium geologicum*," and whose members, rivals as they must be, have only sought to excel each other in their ardent search after truth.

By the choice of my successor you cannot fail to perpetuate this good feeling, for in him you recognize the philosopher, who, passing through other phases, returns to the object of his first love. In him you applaud one of the founders of your Society, a munificent supporter of geological works requiring assistance, one of your earliest contributors, and one, I will add, of the best Secretaries you ever had—whether as respected the performance of his own duties or the singleness of mind and integrity of purpose with which, abjuring all personal considerations, he improved the Memoirs of various writers which found their way into your Transactions. His fitting reward,

therefore, is this Chair, which I resign to him in the full persuasion that he will view it, as I have done, in the light of the highest honour to which a geologist can aspire; and that as one of our old and sincere friends, he will ever be imbued with the strongest motives for preserving the harmony and prosperity of the Geological Society.

THE END.

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