



XXXII. Researches on some of the revolutions which have taken place on the surface of the globe; presenting various examples of the coincidence between the elevation of beds in certain systems of mountains, and the sudden changes which have produced the lines of demarcation observable in certain stages of the sedimentary deposits

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XXXII. *Researches on some of the Revolutions which have taken place on the Surface of the Globe; presenting various Examples of the Coincidence between the Elevation of Beds in certain Systems of Mountains, and the sudden Changes which have produced the Lines of Demarcation observable in certain Stages of the Sedimentary Deposits.* By L. ELIE DE BEAUMONT*.

TWO great views, one a succession of violent revolutions, the other the elevation of mountain-chains by forces acting from beneath, having been successively introduced into geology, it was natural to inquire if they were independent of each other; if mountain-chains could be raised without producing real revolutions on the surface of the globe; if the frightful convulsions which must have accompanied the up-burst of masses so great and of an aspect so contorted as those of high mountains, were not the same with those revolutions on the surface of the globe which are proved to have taken place by the mineralogical and zoological lines of demarcation observable in the sedimentary deposits.

The principal object of the researches, of which the following is a brief sketch, is to show, term for term, the connection of these two series of facts.

It will be necessary to premise a few words respecting the principles on which these researches have been conducted. The expression *sedimentary deposits* (*terrains de sediment*) in which we, in some measure, sum up our knowledge of those masses so widely spread over the surface of our planet, so

* Extract forwarded to Mr. De la Beche in May 1831, and communicated by the latter to the Editors.

naturally carries with it the idea of *horizontality*, that it is never without surprise we first hear of sedimentary beds observed in a vertical or nearly vertical position.

As early as 1667, Stenon maintained that all inclined sedimentary beds were upraised; and since the observations of De Saussure on the Valorsine conglomerates, geologists have generally agreed in considering those sedimentary beds which are frequently observed in mountainous countries either inclined at considerable angles, placed vertically, or even thrown over, as not having been formed in that position, but as having been so circumstanced, in consequence of phænomena which have taken place at a greater or less time after their original deposition.

There are few countries where these phænomena have been produced at so late a period, as to affect all the sedimentary deposits there existing, even abstracting the alluvion of modern rivers, which in all cases has not yet been disturbed by any phænomena of this nature.

We observe along nearly all mountain chains, when we attentively examine them, that the most recent rocks extend horizontally up to the foot of such chains, as we should expect would be the case if they were deposited in seas or lakes of which these mountains have partly formed the shores; whilst the other sedimentary beds tilted up, and more or less contorted on the flanks of the mountains, rise in certain points even to their highest crests. Thus in each chain, or rather in each system of chains, the series of the sedimentary rocks is divided into two distinct classes, and the point of separation of these two classes, variable from one system to another, is one of the circumstances which best characterizes each particular system.

At the same time that the position of the ancient and inclined beds furnishes the best proof of the elevation of the mountains of which they constitute a part, the geological age of these beds affords the best means of determining the relative age of the mountains themselves; for it is evident, the first appearance of the chain itself is necessarily intermediate between the period when the beds, now upraised, were deposited, and that when the strata were produced horizontally at its feet.

There is nothing so essential to remark, as the constant clear line of separation between these two series of beds in each chain. This kind of observation is sanctioned by long experience. Geologists have, in fact, been long accustomed to employ the absence of parallelism in the stratification of two systems of beds, the one supporting the other, as affording the

the clearest line of demarcation that can be found between two systems of consecutive sedimentary deposits. This idea, which has been developed in the lessons of the most distinguished professors, has, it may be said, become common. It was indeed on a fact of this nature, generalized certainly beyond measure, that Werner founded his principal division in the series of rocks. Now it follows from this difference, always clear and without passage, between the upheaved beds and those which are horizontal, that the elevation of the beds has not been effected in a continuous and progressive manner, but that it has been produced in a space of time comprised between the periods of deposition of the two consecutive rocks, and during which no regular series of beds was produced;—in a word, that it was sudden, and of short duration.

It has been in vain attempted to explain the geological facts observable in high mountain-chains, by the action of the slow and continuous causes now in force on the surface of the globe. No satisfactory result has been obtained by these means. In fact, everything shows that the instantaneous elevation of the beds of a whole mountain-chain is an event of a different order from those which we daily witness. It is evident that such a convulsion would interrupt the slow and progressive formation of the sedimentary deposits, and that some anomalous circumstance would be nearly universally observable in that point of the series of rocks which should correspond with the moment when an elevation of beds took place. It is well known that those geologists who have most carefully examined the sedimentary deposits, and those naturalists who have investigated the remains of animals and vegetables which they contain, have generally remarked that between different terms of the series of these rocks there are sudden variations, not only in the position and local character of the beds, but also in the fossil animals and vegetables entombed in them. From observations which did not comprise a sufficiently extensive area, some of these variations (to lessen the value of which too many attempts have perhaps been subsequently made) were at first supposed more general than they really are. When two formations appear to pass insensibly into each other, there is never more than a small depth of beds of which the classification may remain uncertain; and when certain fossils are common to two successive formations, they generally constitute a fraction, often even inconsiderable, of the total number of species found in each of the two formations. This is more particularly seen in the comparison instituted by M. Deshayes (in a work impatiently expected by geologists) between the catalogues of the species of shells
2 I 2 discovered

discovered in the three groups, which he distinguishes in the beds above the chalk, and the catalogue of species now existing. It is sufficient, that in the series of superimposed beds there are points more remarkable than others, on account of the changes they exhibit, both in the deposits and in the inhabitants of the same country, to be struck with the accordance of the two orders of considerations above noticed.

Among those observations which render it impossible to consider the dislocation of beds which characterizes a mountainous country as the result of local phenomena, which may have been repeated in an irregular and successive manner, we may place in the first rank the constancy of the direction in which sedimentary beds are tilted up even for immense distances.

Practice has taught miners from time immemorial the principle of constancy in directions, and it is one of those circumstances which they most usefully employ in their researches. The observation of constancy in the direction of beds in the coal-measures, has served to discover a bed of coal at a distance, though invisible on the surface. It was by combining the observations made in numerous metallic mines, that Werner arrived at the conclusion, that, in the same district, all the veins of the same nature were due to cracks parallel to each other, formed at the same time, and subsequently filled at the same period. The remarkable phenomenon of constancy of direction has been gradually shown to be more important, by the labours of those geologists who since De Saussure and Pallas have attentively examined mountain chains. It has been admitted by degrees, that the circumstance which best characterizes mountain-chains, when compared with each other, is the direction which the elevation of the beds has impressed upon them,—a direction naturally observable in the crests composed of such beds. For more than thirty years M. Humboldt has pointed out the equally remarkable accordances and discrepancies observable in the direction of mountain-chains, whether close to, or remote from, each other. M. von Buch has also shown that the mountains of Germany are divisible into at least four systems, clearly distinguishable from each other by their directions. So clear a mode of distinction even led him to conceive that the various mountain systems were produced by phenomena independent of each other; and it is at the same time very probable, that not only, as is proved by observation, all beds upheaved at the same time have been so raised in the same direction, but also that this constancy in the direction of the upraised beds in a certain assemblage of mountains, is the result of this collection
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of beds having been thrown up at the same time by a single effort of nature: whence it would follow that the number of the epochs of elevation would not be unlimited, but that it would at least be equal to that of the directions of those chains which are clearly distinct,—a number not incompatible with that of the solutions of continuity observable in the sedimentary deposits.

It became necessary, in order to carry the subject beyond these vague and general views, that a comparison should be instituted between the number of those lines of demarcation observable in the sedimentary deposits, and the same number of mountain systems. It has been attempted to accomplish this by combining the two great principles above noticed; namely, that the highly inclined sedimentary beds are upheaved strata, and that in each mountainous district all the beds upheaved at the same moment have been so raised in the same general direction.

The examination of the surface of Europe has in this manner already led to the determination, both with respect to age and direction, of the twelve systems of mountains to be successively noticed in the sequel, as also their relation to twelve solutions of continuity observed in the series of sedimentary deposits.

I. System of Westmoreland and of the Hundsruck.—The correspondence of this nature which may be referred to the most ancient geological epoch has been made known by the researches of Professor Sedgwick, recently communicated to the Geological Society of London. The mean line of bearing of the different systems of slate rocks in the lake mountains of Westmoreland, is shown by this author to be nearly N.E. by E., and S.W. by W. This causes them to abut successively against the carboniferous zone; from which it follows that they must also be unconformable to it. Professor Sedgwick strengthens this inference by reference to detailed sections: and from the whole of the evidence he concludes, that the central lake mountains were placed in their present position, not by a long continued, but by a sudden movement of elevation, before or during the period of the old red sandstone*.

Professor Sedgwick has also shown that if lines be drawn in the principal bearing of the following chains,—viz. the southern chain of Scotland, from St. Abbs Head to the Mull of Galloway; the grauwacké chain of the Isle of Man; the slate ranges of the Isle of Anglesea; the principal grauwacké

* From other circumstances to be noticed in the sequel, it appears very probable that this movement of elevation was anterior to the deposition of the most recent strata of the transition series.

chains of Wales, and the Cornish chain,—they will be nearly parallel to each other and to the line of bearing of the lake mountains. The elevation of these chains, which produce marked effects on the physical character of Great Britain, is referred by Professor Sedgwick to the same period; and the parallelism is not considered accidental, but as offering a confirmation of the general principle,—that mountain-chains, all elevated at the same period of time, present a general parallelism in the bearing of their component strata.

The surface of continental Europe presents many mountainous countries, in which the predominant direction of the most ancient and disturbed beds is, as has been remarked for more than thirty years by M. Humboldt, but slightly removed from a N.E. and S.W. line. Such is, for example, the direction of the grauwacké and slate beds in the mountains of the Eiffel, the Hundsruok, and of Nassau, at the feet of which were probably deposited the coal-measures of Belgium and Saarbruck. Such is also the direction of the slate, grauwacké, and transition limestone beds of the northern and central parts of the Vosges, on the edges of which there are several small coal basins.

The parallelism of this direction to that observed by Professor Sedgwick in England, added to the fact, that in the Vosges this direction of the slate and grauwacké strata is not carried into the coal-measures, leads us naturally to suppose that the inclined position of these parallel beds of England and the Continent is due to the same catastrophe, the most ancient of any of which traces can at present be clearly recognised.

Further researches may perhaps show the relation that may exist between the different parts of the Westmoreland slate rocks, and more effaced and older elevations of strata than this now under consideration.

II. *System of the Ballons (Vosges) and of the Hills of the Bocage (Calvados).*—The observations noticed in the preceding article, only prove that the system of Westmoreland and the Hundsruok have been elevated before the deposition of the carboniferous series; but it would appear that it had been elevated even before the deposit of the more recent transition rocks. In fact, among those beds which we are in the habit of comprising in the general denomination of transition rocks, there is a widely extended class which has not been affected by the N.E. and S.W. elevation of the ancient slates, and which may have been deposited on these beds, previously upheaved. Such are the marly and arenaceous limestones with *Orthoceratites*, *Trilobites*, *Hysterolites*, &c. which occur in Podolia, in the environs of St. Petersburg, in Sweden, and in Norway, where

where they are in general but slightly removed from their original horizontal position. Such are also the transition rocks, so rich in organic remains, of Dudley and Gloucestershire, which appear to have been deposited at the foot of the previously elevated mountains of Wales, and which are themselves only affected by dislocations of a more recent date.

Such would also appear to be a part of the transition beds of Southern Ireland, known by the recent researches of Mr. Weaver. This distinguished geologist remarks that some parts of the system resemble, both in mineralogical and zoological characters, the rocks of Tortworth in Gloucestershire. The principal rock masses in the South of Ireland are composed of grauwacké, quartz rock, and limestone; they contain crinoidal remains, *Trilobites*, *Orthoceratites*, *Ellipsolites*, *Ammonites*, *Euomphalites*, *Turbinites*, *Neritites*, *Melanites*, and several species of *Terebratula*, *Spirifer*, *Producta*, and other bivalves, *Hysterolites*, and many genera of *Polyparia*. The anthracite and accompanying pyritiferous strata are charged with the remains or impressions of plants, belonging chiefly to the genera *Equisetum* and *Calamites*, with traces of *Fucoides*.

The transition rocks of the Bocage (Calvados) and the interior of Brittany bear a great resemblance to those described by Mr. Weaver in the South of Ireland. They are like them composed of numerous beds of slate, grauwacké, quartz rock, and limestone, containing fossils of the same class, and presenting mines of anthracite.

Finally, I am induced to refer to the same epoch the slate and grauwacké rocks with anthracite (worked for profitable purposes, and which contain vegetable impressions differing but little from those discovered in the coal-measures), which form the S.E. angle of the Vosges, and which appear to rest against the granitic masses of the environs of Gerarmer, Remiremont, and Tillot; masses which probably were themselves raised at the formation of the old N.E. and S.W. lines of elevated strata. Independently of the geological relations which are apparent between the different parts of the vast deposit of transition rocks above noticed, they have also in common remained unaffected by the ancient N.E. and S.W. system.

When these beds are not horizontal, they are dislocated in directions the most marked of which, probably produced immediately after their deposit, is comprised between an E. and W. line and one E. 15° S. and W. 15° N. Thus the masses of granite and porphyry which, in the S.E. part
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of the Vosges, constitute the summits of the Ballon d'Alsace and the Ballon de Comté, range from E. 10° or 15° S. to W. 10° or 15° N., and have thrown up the anthracitic rocks in this direction. The coal-measures of Ronchamps are deposited at the foot of these mountains on the edges of the upheaved beds. The Ballon d'Alsace rises 2586 English feet above the town of Giromagny, built on a level with the coal-measures; and the Ballon de Gebweiler, situated more to the N.E., rises 3067 English feet above the same point. Among those inequalities on the surface of the globe, the date of which we can with probability refer to so remote an epoch, we cannot cite any more considerable.

The transition beds of Brittany and of the Bocage of Normandy, on which the coal-measures of Littry and Plessis are deposited, run in a direction comprised within the above-mentioned limits, as is also the case with the transition beds of Ireland, so ably described by Mr. Weaver. The South of Ireland is a hilly and diversified region, composed of ridges having generally an east and west direction, and attaining their greatest elevation in the mountains of Kerry, where Gurran Tval, one of Magillicuddy's Reeks, near Killarney, rises 3410 feet above the sea. The transition rocks of the same region have a general direction from east to west, and dip to the north and south with vertical beds in the axes of the ridges. The strata, as they diminish in inclination, on each side form a succession of troughs, the beds dipping rapidly to the north or south, and bending to horizontality between the ridges.

These rocks decline gradually towards the north, and finally pass beneath the unconformable deposits of the old red sandstone and carboniferous limestone of the midland counties; a discordance rendered particularly striking by the horizontal position of the carboniferous limestone of some districts.

In Devonshire and Somersetshire the grauwacké and slates, sometimes containing small seams of carbonaceous matter, also present a nearly east and west direction, and are seen clearly to have been upheaved previous to the deposition of the Exeter red conglomerate or *todte liegende*, because the latter covers the edges of the former, as may be seen in many situations.

The grauwacké chain of Magdeburg has also a direction comprised within the above-noticed limits; and according to the observations of Professor Sedgwick and Mr. Murchison, it contains the abundant impressions of true coal plants. This same direction is again observed in the older rocks of the Hartz, where we are certain that the dislocations were in part
 effected

effected prior to the deposition of the secondary beds which extend at the foot of the mountains; and particularly before the formation of the coal-measures of Ilfeld.

This system, joined to that previously noticed, and perhaps also to others which have not yet been studied, has produced an undulated surface and a dislocated structure in the ancient land (*ur und uebergangsgebirge*), in the inequalities of which the first beds of that mass of rocks was deposited which Werner named *floetz gebirge*, and the English and French geologists secondary deposits, deposits of which the carboniferous series (old red sandstone, mountain limestone, and coal-measures) constitutes the lowest part.

III. *System of the North of England.*—From the latitude of Derby to the frontiers of Scotland, the surface of England is divided by a mountainous axis, which, taken as a whole, runs nearly from south to north, stretching a little towards the N.N.W. In that chain which, being wholly formed of beds of the carboniferous series, is called the great carboniferous chain of the North of England, the forces of elevation appear on the whole to have acted (though not without considerable deviations) on a line bearing nearly north and south (inclining but a few degrees to the N.N.W. and S.S.E.). Hence great faults have originated, by one of which its western limit is tracked through the Peak of Derbyshire. This is prolonged through an anticlinal line into the high western moors of Yorkshire, and there the western escarpment of the chain is accompanied by enormous breaks from the heart of Craven to the foot of Stainmoor. Another enormous break, passing under the escarpment of the Cross-fell range, meets the prolonged line of the Craven fault at an obtuse angle near the foot of Stainmoor. By this last fault the insulated position of the lake mountains is at once explained.

In Professor Sedgwick's memoir, whence the above is derived, we find direct proofs that all the fractures above mentioned took place immediately before the formation of the conglomerates of the new red sandstone (*rothe todte liegende*), and he affords the strongest reasons for believing that they were produced by an action both violent and of short duration; for we pass at once from the inclined and disrupted masses to the horizontal conglomerates now resting upon them; and there is no trace of any effect that indicates a slow progress from one system of things to the other. Lastly, Professor Sedgwick, speculating on the origin of the phenomena described, points to the different crystalline rocks which appear near the carboniferous chain (toadstone of Derbyshire, and whinstone of Cumberland).

The elevation of the chain of the North of England has very probably not been an isolated phænomenon. If we glance at the geological map of England by Mr. Greenough, and that which accompanies the memoir of Dr. Buckland and Mr. Conybeare on the environs of Bristol, we are naturally led to remark that the problematical rocks which pierce and dislocate the coal deposits of Shrewsbury and Colebrooke Dale, and those which constitute the Malvern Hills, appear connected with a series of fractures which run nearly north and south, being prolonged across the recent transition beds and the carboniferous rocks to the environs of Bristol.

The coast, with a north and south direction, which bounds the western part of the department of La Manche, may probably also be due to a fracture of the same class as those of the great carboniferous chain of the North of England.

IV. *System of the Pays Bas and of South Wales.*—From the environs of Aix-la-Chapelle to the small isles of St. Bride's Bay, Pembrokeshire, over a length of about four hundred English miles, the different portions of the carboniferous series, wherever they are not concealed from observation by more recent formations, are seen in a greater or less state of complete dislocation. There are situations, as at Liège, Mons, Valenciennes, the Bouloguais, and the Mendip Hills, where they have suffered very considerable contortions and dislocations. Throughout a large portion of this extent, these beds, which in no part rise to great heights, are covered by more recent deposits, resting horizontally on their edges. The vast sheet of recent deposits which covers the carboniferous series between the environs of Boulogne and those of Bristol, might even throw doubt on the mutual connection of the dislocations in the Pays Bas and the coasts of the Bristol Channel: it is nevertheless certain that the dislocations in both situations possess common characters; such as not widely differing from an east and west direction, without however preserving the same line of bearing for great distances, and only producing small protuberances on the surface of the land, notwithstanding the contortions of the beds in the interior.

In the environs of Liège and Aix-la-Chapelle, the direction of the carboniferous beds becomes nearly parallel to that of the argillaceous slates and grauwacké of the Eiffel and the Hunsrück; but it is probable that this arises from the fractures of the carboniferous series having been inflected in such a manner as to follow the ancient dislocations of the pre-existing rocks; for it would be difficult not to admit, from the facts previously noticed, that the elevation of the slate and grauwacké of the Eiffel and the Hunsrück, following a direction
nearly

nearly N.E. and S.W., was not referrible, like that of the analogous rocks in Westmoreland, to a much more remote epoch.

The dislocation of the coal-measures of Saarbruck is also probably referrible to the same epoch as that of Glamorganshire and the Pays Bas, as it offers nearly the same direction and characters.

In the environs of Bristol the magnesian conglomerate horizontally covers the edges of the dislocated carboniferous beds, and the *grès de Vosges* is seen at Saarbruck in the same position. The elevation of the beds now under consideration ought therefore to be anterior to the deposition of the magnesian conglomerate of Bristol and of the *grès de Vosges*; but as the *totde-liegendes* (*grès rouge*), properly so called, does not on any point rest on the carboniferous beds elevated in the direction in question, we may be permitted to presume that their elevation took place after the deposit of the *totde-liegendes*.

V. *System of the Rhine.*—The Vosges and the Swartzwald form two groups of mountains, to a certain extent symmetrical, terminating one opposite the other in two long cliffs, the general directions of which are parallel to each other, and to the course of the Rhine which flows between them from Bâle to Mayence. These two cliffs, between which extends the great valley of Alsace, are the most clearly defined characters of that assemblage of mountains which M. von Buch has grouped together under the name of the system of the Rhine. They are partly formed by beds of the *grès de Vosges*, and appear due to great fractures or faults, with a direction nearly S. 15° W., and N. 15° E., which have broken them after their deposition. The epoch of this disturbance has necessarily preceded that of the deposition of all those beds which extend from one cliff to the other, forming the slightly undulating base of the basin of Alsace, and among which occur the red or variegated sandstone (*grès bigarré*), the muschelkalk, and the variegated marls (*marnes irisées*). The last three formations have extended round the mountains constituting the system of the Rhine, and mark out the winding of the coasts, bathed by the sea during that period of tranquillity which succeeded those commotions, the effects of which have been so well preserved.

VI. *System of the South-west coasts of Britanny, of La Vendée, of Morvan, of the Böhmerwaldgebirge, and of the Thüringerwald.*—The oolitic series, comprising the lias and its inferior sandstone, has been deposited in an assemblage of seas and gulfs which marks out the windings of the various systems of mountains above noticed, and at the same time those of a peculiar

system, distinguished by the N.W. and S.E. direction of the greater part of its ridges and valleys, and by the beds of the red or variegated sandstone (*grès bigarré*), the muschelkalk, and the variegated marls (*marnes irisées*) being thrown out of their original position, as well as all the more ancient rocks. In the centre of France, near Avallon and Autun, the granitic and porphyritic protuberances of Morvan stretch from N.W. to S.E., disturb the coal-measures, and raise a peculiar *arkose*, contemporaneous with the variegated marls, to their summits; whilst the lias and another *arkose*, which forms its lowest part, extend horizontally to the feet of the same protuberances and form the plains which surround them. The same direction, and in part the same geological circumstances, are observable in the hills, partly granitic, of the S.W. coast of Brittany and La Vendée. These circumstances also appear in that part of the Böhmerwaldgebirge which separates Bavaria from Bohemia, in the Thuringerwald, and in the lines of disturbance in the muschelkalk and the variegated marls (*keuper*) which according to the excellent map of M. Hoffmann run in the same manner from S.E. to N.W. across the nearly flat countries situated between the Hartz and the Taunus. It therefore appears that the elevation of the different parallel chains above mentioned, is referrible to that revolution on the surface of the globe to which the sudden difference observable between the variegated marls and the lias is due.

VII. *System of the Pilas, the Côte d'Or, and of the Erzgebirge.*—Professor Sedgwick has summed up, in his last Address to the Geological Society of London, our knowledge respecting this system. It includes (in Eastern France) the higher elevations of the Côte d'Or and Mont Pilas, the Cevennes, and a portion of the Jura chain. It may be traced towards the valley of the Rhine, where it is suddenly cut off; but it reappears in the chain of the Erzgebirge, between Bohemia and Saxony. It never rises into mountains of the first order, but is marked throughout (as may be seen on a good physical map) by many longitudinal ridges and furrows, ranging nearly parallel to each other in a direction about north-east and south-west. So far the statement is only an enumeration of certain connected facts in physical geography. But it is followed by a coordinate series of geological phenomena.

A number of formations, including in the ascending order the whole oolitic series, enter here and there into the composition of the geographical system above described; and, without exception, wherever they appear all are in turn elevated, broken, or contorted; yet in their lines of range they preserve a parallelism to the general direction of the ridges. On the

the contrary, wherever rocks of an age not older than that of the green-sand or chalk, appear in the vicinity of any portion of this system, they are either found at a dead level and expanded from the neighbouring mountains into horizontal planes, like the sea at the base of a lofty cliff; or if, since their first deposit, they have undergone any great movement, it is shown to have no relation to the bearing of the older ridges, and to have been produced at a later period.

From all these combined facts follow three important consequences. 1st, That the whole system of parallel ridges, from one end to the other, was elevated at the same period of time, after the development of the oolitic series, and before the deposition of the green-sand and chalk. 2ndly, That the action of elevation was violent and of short continuance, for the inclined strata are shattered and contorted; and between them and the horizontal strata there is no intermediate gradation of deposits. 3rdly, That the period of elevation was followed by an immediate change in many of the forms of organic life.

VIII. *System of Mont Viso*.—The French Alps and the S.W. extremity of the Jura, from the environs of Antibes and Nice to those of Pont d'Ain and Lons-le-Saulnier, present a series of crests and dislocations with a direction towards the N.N.W., in which the older beds of the Wealden formation, the green-sand, and the chalk, are upheaved as well as those of the oolitic series. The pyramid of primitive rocks of Mont Viso is traversed by enormous faults, which from their direction evidently belong to this system of fractures. The eastern crests of the Devolny, north from Gap, are composed of the most ancient beds of the system of green-sand and chalk, thrown up in the direction in question, and elevated more than 4700 English feet above the level of the sea. At the feet of these enormous escarpments, are horizontally deposited, near the Col de Bayud, and at more than 2000 feet lower down, those upper beds of the cretaceous system which are distinguished from the rest by the presence of *Nummulites*, *Cerithia*, *Ampullaria*, and other shells, the genera of which were long considered as not extending deeper in the series than the tertiary rocks. Thus it was between the two portions of that which is commonly termed the series of the Wealden formation, green-sand, and chalk, that the beds of the Mont Viso system have been upraised.

IX. *Pyreneo-Apennine System*.—Professor Sedgwick presented a summary of this system, in his last Address to the Geological Society of London, and I must not omit to mention that important parts of the whole evidence were added by Professor Sedgwick himself and Mr. Murchison, during their

their last travels on the Continent. This system includes the whole chain of the Pyrenees, the northern and some other ridges of the Apennines, the calcareous chains to the N.E. of the Adriatic, those of the Morea, nearly the whole Carpathian chain, and a great series of inequalities continued from that chain through the N.E. escarpment of the Hartz mountains to the plains of Northern Germany. Through the whole of these vast regions the principal inequalities range nearly parallel to each other, and have a mean bearing about west-north-west and east-south-east. So far again the statement is purely geographical, and its truth is seen at once in glancing over any good physical map of Europe; and will be still more clearly comprehended, by comparing some of the principal ranges of colour on Von Buch's great geological map with the bearing of the Pyrenees. But it is followed by a series of co-extensive geological phenomena.

Through all parts of this great system, formations of the age of the green-sand and chalk have had an enormous development, and without exception, their strata are ruptured and contorted, and often lifted up to the very pinnacles of the mountains. But on the contrary, wherever any tertiary formations approach the confines of this system, they are stated to be either in a position almost as horizontal as the surface of the waters in which they were deposited; or if they have been moved at all, it is by forces uninfluenced by the parallels of the older chains. And the same three conclusions, with a mere difference of dates, follow here as in the former case. All the great parallel ridges and chains of this second system must have been suddenly and violently elevated, and at a period of time between the deposition of the chalk and the commencement of the tertiary groups; and the corresponding change in organic types is, in this instance, still more striking than in the former.

X. *System of the Islands of Corsica and Sardinia.*—The beds named tertiary are far from constituting a continuous whole. Many interruptions are observable in them, each of which may have corresponded with an elevation of mountains effected in countries more or less near our own.

An attentive examination of the nature and geographical disposition of the tertiary rocks in the north and south of France, has led me to divide them into two series: one, which is composed of the plastic clay, the *calcaire grossier*, and the whole gypseous formation, including the upper marine marls, scarcely passes to the S. or S.W. of the environs of Paris; whilst the other, represented in the North by the *grès de Fontainebleau*, the upper freshwater formation, and the *fahluns*, comprises,

comprises, with few exceptions, nearly the whole tertiary deposits of the South of France and Switzerland, and especially the lignite deposits, such as those of Fureau (*Bouches du Rhone*), and Kœpfnach (Switzerland). The *grès de Fontainebleau*, resting on the marls of the gypseous formation, is the lowest portion of this series, in the same manner that the lias sandstone, resting on the variegated marls (*marnes irisées*), is the lowest portion of the oolitic series. The former is to the tertiary *arkose* of Auvergne, what the latter is to the Jurassic *arkose* of Avallon. The two tertiary series are not less distinguished by the remains of the large animals which they contain, than by their mode of occurrence. Certain species of *Anoplotherium* and *Palæotherium* discovered at Montmartre, characterize the former, whilst other species of *Palæotherium* and nearly all the species of the genus *Lophiodon*, the whole genus *Anthracotherium*, and the more ancient species of the genera *Mastodon*, *Rhinoceros*, *Hippopotamus*, *Castor*, &c., characterize the latter.

The line of demarcation existing between the first and second of these tertiary series would appear to correspond with the elevation of the system of mountains under consideration, the predominant direction of which is from north to south. The beds of the second series are, in fact, those which alone mark out the boundaries of the mountains.

Among the dislocations with a north and south direction, we find the chains which border the high valleys of the Loire and Allier, in a similar line of bearing to which are the volcanic masses of the Dome mountains, and at the bottoms of which the fresh-water rocks of Limagne, of Auvergne, and of the high valley of the Loire have been accumulated. The valley of the Rhone which, quitting Lyon, also runs in a north and south direction, is in like manner filled up to a certain level by a tertiary deposit, the inferior beds of which, analogous to those of Auvergne, are also of fresh-water origin, while the upper beds are marine, and in a great measure correspond with the *fahluns* of Touraine.

The same direction is observable in the islands of Corsica and Sardinia, in many valleys and small chains of the Apennines and of Ystria, in the disposition of many volcanic masses and metalliferous sites of Hungary, and the chain which, commencing in the middle of Servia with the Caponi, is prolonged, parallel to the meridian between Macedonia and Thessaly on the one side, and Albania on the other, bordering the valleys of the Drino and the Arta on the east.

It is worthy of remark, that the directions of the system of the Pylas and the Côte d'Or, of the system of the Pyrenees, and

and that of the islands of Corsica and Sardinia, are respectively nearly parallel to those of the system of Westmoreland and the Hunsrück, of the system of the Ballons and the hills of the Bocage, and of the system of the North of England. The corresponding directions only differ in a few degrees, and the two series have succeeded each other in the same order; leading to the supposition that there has been a *kind of periodical recurrence* of the same, or nearly the same, directions of elevation.

XI. *System of the Western Alps*.—The opinions in accordance with which M. Jurine named the granitic rock constituting Mont Blanc *Protogine*, can no longer be sustained. The tertiary beds which have been deposited horizontally in that part of the valley of the Rhone which runs N. and S. are constantly contorted and thrown up as they approach the Alps. A similar observation has been made in the valley of the Danube by Professor Sedgwick and Mr. Murchison, who found the cretaceous and tertiary beds to extend horizontally to the foot of the Bohemian mountains, and to be thrown up on entering the Austrian Alps. Messrs. Lyell and Murchison have made analogous observations on the tertiary rocks of Lombardy. Professor Buckland and M. Brongniart have pointed out the tertiary aspect of the fossil shells discovered at the Diablerets, at more than 8000 feet above the level of the sea; shells the relative age of which certainly does not go back beyond the last portion of the cretaceous epoch.

Although we are generally accustomed to consider the union of those mountains bearing the single name of *the Alps* as constituting an undivided whole, we can easily recognise that this vast assemblage is due to the crossing of several systems, independent of each other, and distinct both in age and direction. We should therefore not feel surprise that their structure is more confused than that of a chain thrown up by a single effort, such as the Pyrenees. Throughout nearly their whole extent, and especially on their eastern side, we still perceive traces of numerous small chains of mountains with the same direction as the Pyrenees, and elevated in like manner prior to the deposition of the tertiary rocks. The system of Mont Viso is strongly marked in the French Alps. These traces of comparatively ancient dislocations are, however, often marked by disturbances of a more recent date.

The highest and most complicated portions of the Alps, those near the Mont Blanc, Mont Rose, and the Finsteraarhorn, are principally due to the crossing of two recent systems which meet at an angle of from 45° to 50° , and which are distinguishable from the system of Mont Viso and the Pyreneo-Apennine system, as well by their age as their directions. In consequence

consequence of the crossing of these two systems of furrows and ridges, the French Alps form an elbow near the Mont Blanc, and after having followed a direction from E. $\frac{1}{4}^{\circ}$ N.E. to W. $\frac{1}{4}^{\circ}$ S.W. from Austria to the Valais, they suddenly turn to fall into a line from N.N.E. to S.S.W. If there was only a simple curve in a single chain of mountains which merely formed an arch, we should find the direction of the beds to bend and pass from the direction of one of the systems to that of the other. We however observe, that the direction of the beds and crests distinctly belong either to one or to the other, and that the two systems penetrate each other, as we should conceive they must do if they are the productions of two entirely distinct phænomena.

In the Western Alps, that is to say, to the westward of the St. Gothard, and particularly in the mountains of Savoy and Dauphiny, the greater part of the dislocations are referrible to two systems of ridges, the mean direction of which is N.N.E. and S.S.W., or more exactly N. 26° E., and S. 26° W. The constant direction of the beds in these mountains has long since been remarked by De Saussure, and more recently by M. Brochant; and they with reason concluded, that in all those parts where this direction predominated, the beds were thrown up by a single operation of nature.

It is easy to determine the geological date of this event; for we have only to examine what are the formations which have been disturbed, and what the deposits which extend horizontally on the edges of the dislocated and more ancient strata.

In the interior of that system of ridges of which the Western Alps are principally composed, we do not find beds more recent than the chalk, because these ridges have been formed on a surface previously made mountainous, at the epoch of the systems of Mont Viso and the Pyrenees. But on the skirts, as also at the two extremities of the space occupied by the ridges to which the character of the Western Alps is due, we find that the dislocations which have produced the ridges are carried into the most recent tertiary deposits, as well as into the secondary rocks which support them: whence it follows, that the elevation of the beds in the system of the Western Alps took place after the deposit of those recent tertiary beds, named shelly molasse (*mollasse coquillière*), beds contemporaneous with the *fahluns* of Touraine.

XII. *System of the principal Chain of the Alps (from the Valais to Austria), comprising also the Chains of the Ventoux, the Liberon, and the St. Baume (Provence).*—The valleys of the Isère, the Rhone, the Saone, and the Durance, present two very distinct detrital and transported formations, between

which there is a want of continuity, and a sudden variation of character, constituting a new interruption in the series of sedimentary deposits.

The waters which have transported the materials of the first of these formations would appear to have been received into lakes of fresh water which covered, in one direction, the N.W. portion of the department of the Isère, La Bresse, and perhaps, Alsace, and even the environs of the lake of Constance; and in the other, the portion of the department of the Basses Alpes between Digne, Manosque, and Barjols: whilst the materials of the second formation appear to have been violently carried by temporary currents which have discharged themselves into the Mediterranean. These latter currents are generally known as *diluvial currents*, though they offer nothing in common with the Deluge of history, and though their passage took place before the human race appeared on our continent, where they destroyed animals of species now extinct. Discussions will still perhaps be carried on respecting their origin, which may have merely been the result of the melting of the snows, instantaneously effected when the principal chain of the Alps was elevated; but it seems generally admitted that their passage immediately followed the last dislocation of the Alpine strata.

If we cast a general glance on the Alps and neighbouring countries, we may observe that the crests of the St. Baume, the Lebaron, the Ventoux, and the Montagne de Poet, in the South of France, the principal chain of the Alps from the Valais to Austria, and the less elevated crest, comprising the Pilate, &c. in Switzerland, are so many different chains, which, notwithstanding their inequality, are comparable with each other both as respects their parallelism and their common analogies to the system of the Western Alps. This parallelism and these analogies would alone afford us powerful reasons for believing that the whole of these mountain-chains were formed at the same time, and are only different parts of a single system of fractures produced at the same moment. We can at furthest conceive the idea of dividing them into two groups,—that of Provence, and that of the Alps; but we are prevented from doing this by the analogous relations observable among the different fractures, and by a general movement which we may consider the surface of a part of France to have suffered when it contracted a double slope; ascending in one direction from Dijon and Bourges towards Le Forez and Auvergne, and on the other from the shores of the Mediterranean towards the same countries. These opposed slopes present at their junction a kind of crest, situated precisely in the line of elevation

tion of the principal chain of the Alps. This line, which may be observed to run in a more or less marked manner from the confines of Hungary to Auvergne, appears to be connected with the principal anomalies unveiled in the interior structure of our continent by geodesical measurements and observations with the pendulum. We may even suppose that the formation of this line gave, as it were, the signal for the appearance of the craters of elevation of the Cantal and Mont d'Or, round which the volcanic cones of Auvergne have been subsequently thrown up.

The two opposite slopes, above mentioned, were not produced until after the existence of those lakes in which the older transported substances were accumulated; for it can be ascertained that the bottom of the lake which covered La Bresse and the N.W. portion of the department of the Isère has suffered a considerable elevation from the north towards the south, and that the bottom of the lake which extended between Digne, Manosque, and Barjols, has been elevated to a great degree from the south towards the north.

The ancient deposits of transported substances, forming horizontal beds at the bottom of the latter of these lakes, on the edges of tertiary deposits, previously dislocated when the Western Alps were thrown up, are in their turn dislocated near Mezel (Basses Alpes) in the direction of the small chains which ridge Provence, such as the Ventoux and Lebaron, parallel to the principal chain of the Alps.

To determine the date of this last order of dislocations it will be sufficient to remark, that the diluvian deposit is in no part affected; that it covers the edges of the dislocated beds with no other slope than that which the current impressed on them at their origin; and that thus the elevation of the beds in question necessarily took place between the older deposit of transported substances and the passage of the diluvian currents.

If we attentively consider, on a terrestrial globe of sufficient size and good execution, the most prominent and the most recent systems of mountains which ridge Europe, we may remark that each of them forms a part of a vast system of parallel chains, which extends far beyond the countries geologically known to us. But as in all the parts of each of these systems situated in well examined portions of Europe, it has been more and more observed that parallel chains are in general contemporaneous, there is no reason to suppose that this law should suddenly cease, if its verification should be pushed still further. It is therefore natural to consider, until direct observations may show the contrary, that each of

these vast systems, of which the European systems are respectively portions, originates in a single epoch of dislocation. From this view I am led to suppose, for example, that the principal chain of the Alps is contemporaneous with a vast assemblage of mountain-chains which spread round the Mediterranean, and being prolonged across the continent of Asia, run parallel to a great circle which should pass through the middle of Morocco and the north of the Birman empire, and appear at the same time connected with each other by parallelism and by the similarity of their relations to the great depressions of surface filled by the sea, or but slightly raised above its level. Besides the principal chain of the Alps, and the small chains of Provence, this system comprises, in Europe, the Sierra Morena, and a large portion of the Spanish chains, on the one hand, and the Balkan on the other: in Africa, it includes the Atlas: in Asia, the central trachytic chain of the Caucasus, crowned by the peak of Elbrouz, more elevated than the Mont Blanc, as also the long series of mountains which under the names of Paropamissus, Indou-Kosh, and Himalaya, bound the plains of Persia and Bengal, and contain the most elevated mountains on the surface of the earth.

I am also led to suppose that the system of the Western Alps constitutes a portion of a vast system, comprising the chain of Kiöl in Scandinavia, the chains which in Morocco run from Cape Tres Furcas to Cape Blanc, and the Littoral Cordilera of Brazil.

Finally, I am led to suppose that the chains of the Pyreneo-Apennine system observed in Europe, form a portion of a vast system comprising certain chains in the north of Africa, of Egypt, of Syria, of the Caucasus, the chains which bound Mesopotamia on the north-east, and even the Ghauts of Malabar, and which appears in another direction, across the Atlantic, in the Alleghanies.

The appearance of a new system of mountains which, judging from the result of our observations, has produced such violent effects on countries near them, could only have exercised an influence in distant countries by the agitation caused in the waters of the sea, and by a greater or less change produced in their level,—events which may be compared to the sudden and passing deluge noticed among the traditions of all nations as having occurred at nearly the same epoch. If this historical event was the last which has taken place on the surface of the globe, we are naturally led to inquire which is the mountain-chain referrible to the same date: and perhaps we may be justified in observing that the chain of the Andes, whose
volcanic

volcanic vents are still in activity, (or more exactly the long cliff (*falaise*) surmounted or bounded by volcanos which run on a great semicircle of the earth from Chili to the Birman country,) presents the most extensive, the most clearly defined, and as it were the least obliterated feature observable in the present exterior configuration of the globe.

It has been shown, as Professor Sedgwick justly observes, that paroxysms of internal energy, accompanied by the elevation of mountains, and followed by mighty waves desolating whole regions of the earth, were a part of the mechanism of Nature; and what has happened again and again, from the most ancient up to the most modern periods, may have happened once during the few thousand years that man has been living on its surface. We have therefore taken away all anterior incredibility from the fact of a recent deluge.

If the general result of the preceding observations be exact, we may briefly express it by saying, that the independence of sedimentary formations is both a consequence and proof of the independence of mountain-systems having different directions. Many traces of interruptions in the series of sedimentary deposits are, perhaps, so slight in Europe, only because they correspond with mountain-systems which, like that so strongly marked on the shores of Mozambique and Madagascar, have not sent any ramifications into our countries.

But if the number of the surface-revolutions of the globe, and of really distinct mountain-systems be still undetermined, and if the series formed by these successive terms be still imperfectly known, the observations already made nevertheless circumscribe within certain limits that law, which when they shall be all completely known may be manifested in their succession. From the circumstance of the present heights of Mont Blanc and Mont Rosa, dating only from the later surface-revolutions of the globe, it is clear, that whatever definitive place other and higher mountains may occupy in the same series, this series will never take that gradually and regularly decreasing form which should lead to the conclusion, that the limit was attained. Nothing will show that phænomena the last paroxysms of which have been so violent should not be reproduced. However provisional the succession of terms may be which results from the preceding memoir, it is difficult to foresee a modification which should so change its aspect, as to lead to the supposition, that the mineral crust of the globe has lost the property of being successively ridged in various directions. It is difficult to conceive a change which would permit us to assure ourselves that the period of tranquillity

quillity in which we live will not be disturbed in its turn by the appearance of a new system of mountains, the effect of a new dislocation of the land we inhabit, and of which earthquakes teach us the foundations are not immovable.

The independence of successive sedimentary formations is the most important result obtained from the study of the superficial beds of our globe; and one of the principal objects of my researches has been to show, that this great fact is a consequence, and even a proof, of the independence of mountain-systems having different directions.

The fact of a general uniformity in the direction of all beds upheaved at the same epoch, and consequently in the crests formed by these beds, is perhaps as important in the study of mountains, as the independence of successive formations is in the study of superimposed beds. The sudden change of direction in passing from one group to another has permitted the division of European chains into a certain number of distinct systems, which penetrate, and sometimes cross each other without becoming confounded. I have recognised from various examples, of which the number now amounts to twelve, that there is a coincidence between the sudden changes established by the lines of demarcation observable in certain consecutive stages of the sedimentary rocks, and the elevation of the beds of the same number of mountain-systems.

Pursuing the subject as far as my means of observation and induction will permit, it has appeared to me, that the different systems, at least those which are at the same time the most striking and recent, are composed of a certain number of small chains, ranged parallel to the semicircumference of the surface of the globe, and occupying a zone of much greater length than breadth; and of which the length embraces a considerable fraction of one of the great circles of the terrestrial sphere. It may be observed in support of the hypothesis of each of these mountain-systems being the product of a single epoch of dislocation, that it is easier geometrically to conceive the manner in which the solid crust of the globe may be elevated into ridges along a considerable portion of one of its great circles, than that a similar effect may have been produced in a more restricted space.

However well established it may be by facts, the assemblage of which constitutes positive geology, that the surface of the globe has presented a long series of tranquil periods, each separated from that which followed it by a sudden and violent convulsion, in which a portion of the earth's crust was dislocated,—that, in a word, this surface was ridged at intervals
in

in different directions; the mind would not rest satisfied if it did not perceive, among those causes now in action, an element fitted from time to time to produce disturbances different from the ordinary march of the phænomena which we now witness.

The idea of *volcanic action* naturally presents itself when we search, in the existing state of things, for a term of comparison with these great phænomena. They nevertheless do not appear susceptible of being referred to volcanic action, unless we define it, with M. Humboldt, as being *the influence exercised by the interior of a planet on its exterior covering during its different stages of refrigeration.*

Volcanos are frequently arranged in lines following fractures parallel to mountain-chains, and which originate in the elevation of such chains; but it does not appear to me that we can thence regard the elevation of the chains themselves as due to the action of *volcanic foci*, taking the words in their ordinary and restricted sense. We can easily conceive how a *volcanic focus* may produce accidents circularly and in the form of rays from a central point, but we cannot conceive how even many united *foci* could produce those ridges which follow a common direction through several degrees.

Volcanic action, such as it is commonly understood, could not therefore be itself the first cause of these great phænomena; but volcanic action appears to be related (and this is a subject which has long occupied M. Cordier, though he has considered it under another point of view) with the high temperature now existing in the earth.

Now the secular refrigeration, that is to say, the slow diffusion of the primitive heat to which the planets owe their spheroidal form, and the generally regular disposition of their beds from the centre to the circumference, in the order of specific gravity,—the secular refrigeration, on the march of which M. Fourier has thrown so much light, does offer an element to which these extraordinary effects may be referred. This element is the relation which a refrigeration so advanced as that of the planetary bodies establishes between the capacity of their solid crusts and the volume of their internal masses. In a given time, the temperature of the interior of the planets is lowered by a much greater quantity than that on their surfaces, of which the refrigeration is now nearly insensible. We are, undoubtedly, ignorant of the physical properties of the matter composing the interior of these bodies; but analogy leads us to consider, that the inequality of cooling above noticed would place their crusts under the necessity of continually

continually diminishing their capacities, notwithstanding the nearly rigorous constancy of their temperature, in order that they should not cease to embrace their internal masses exactly, the temperature of which diminishes sensibly. They must therefore depart in a slight and progressive manner from the spheroidal figure proper to them, and corresponding to a maximum of capacity; and the gradually increasing tendency to revert to that figure, whether it acts alone, or whether it combines with other internal causes of change which the planets may contain, may, with great probability, completely account for the ridges and protuberances which have been suddenly formed at intervals on the external crust of the earth, and probably also of all the other planets.

XXXIII. *On an undescribed Bird of the Family Falconidæ.*

By JOHN BLACKWALL, Esq. F.L.S. &c.*

DURING the last two years, five specimens of a minute Hawk, no account of which, there is reason to believe, has yet been published, have been brought to Manchester, at different periods, from Brazil. On inspecting this new species, it is evident from several peculiarities in its organization, that it should occupy a situation, in a natural arrangement of birds, intermediate between the Hawks and true Falcons; as it unites in itself certain features characteristic of each of those groups. Its short bill, curved from the base, the upper mandible of which is furnished on each side with a small festoon; the shortness of its wings, notwithstanding the second quill-feather is the longest, and the first has the inner web slightly emarginated near its termination; the moderate length of the tail and legs; the reticulated tarsi, and the acrotarsia feathered from the knee to the middle,—plainly indicate that it must be referred to the genus *Gampsonyx*, established by Mr. Vigors.

Order. *Raptores*. Illiger.

Family. *Falconidæ*. Leach.

Subfamily. *Accipitrina*. Vigors.

Genus. *Gampsonyx*. Vigors.

G. Holmii. The bill, which is much curved, is black faintly tinged with blue. Plumage on the forehead and cheeks pale orange; that on the top of the head, back, scapulars and upper part of the wings, dark cinereous brown. Greater wing-coverts and feathers of the spurious wings

* Communicated by the Author.