

## CHAPTER XXIV.

On the relative antiquity of different mountain-chains—Theory of M. Elie de Beaumont—His opinions controverted—His method of proving that different chains were raised at distinct periods—His proof that others were contemporaneous—His reasoning, why not conclusive—His doctrine of the parallelism of contemporaneous lines of elevation—Objections—Theory of parallelism at variance with geological phenomena as exhibited in Great Britain—Objections of Mr. Conybeare—How far anticlinal lines formed at the same period are parallel—Difficulties in the way of determining the relative age of mountains.

### RELATIVE ANTIQUITY OF MOUNTAIN-CHAINS.

THAT the different parts of our continents have been elevated, in succession, to their present height above the level of the sea, is an opinion which has been gradually gaining ground with the progress of science; but no one before M. Elie de Beaumont had the merit even of attempting to collect together the recorded facts which bear on this subject, and to reduce them to one systematic whole. The above-mentioned geologist was eminently qualified for the task, as one who had laboured industriously in the field of original observation, and who combined a considerable knowledge of facts with an ardent love of generalization.

But he has been ambitious, we think unfortunately, of anticipating the march of discovery in reference to the comparative antiquity of different mountain-chains and their supposed connexion with changes in the animate world. His speculations differ entirely from the conclusions to which we have arrived, and we therefore think it necessary to explain fully the reasons of our dissent. In order to put the reader in possession of the principal points of M. de Beaumont's theory, we shall first offer a brief sketch of them, and then proceed to analyze the data on which they are founded.

*Theory of M. Elie de Beaumont.*

1st. He supposes 'that in the history of the earth there have been long periods of comparative repose, during which the deposition of sedimentary matter has gone on in regular continuity, and there have also been short periods of paroxysmal violence during which that continuity was broken.

'2ndly. At each of these periods of violence or "revolution" in the state of the earth's surface, a great number of mountain-chains have been formed suddenly.

'3rdly. All the chains thrown up by a particular revolution have one uniform direction, being parallel to each other within a few degrees of the compass, even when situated in remote regions; but the chains thrown up at different periods have, for the most part, different directions.

'4thly. Each "revolution," or, as it is sometimes termed, "frightful convulsion," has coincided in date with another geological phenomenon, namely, "the passage from one independent sedimentary formation to another," characterized by a considerable difference in "organic types."

'5thly. There has been a recurrence of these paroxysmal movements from the remotest geological periods, and they may still be reproduced, and the repose in which we live may hereafter be broken by the sudden upthrow of another system of parallel chains of mountains.

'6thly. We may presume that one of these revolutions has occurred within the historical era when the Andes were upheaved to their present height, for that chain is the best defined and least obliterated feature observable in the present exterior configuration of the globe, and was probably the last elevated.

'7thly. The instantaneous upheaving of great mountain masses must cause a violent agitation in the waters of the sea, and the rise of the Andes may, perhaps, have produced that transient deluge which is noticed among the traditions of so many nations.

'Lastly. The successive revolutions above mentioned cannot

be referred to ordinary volcanic forces, but may depend on the secular refrigeration of the heated interior of our planet\*.'

It will at once be seen, that the greater number of the above propositions are directly opposed to that theory which we have endeavoured to deduce, partly from the study of the earth's structure, and partly from the analogy of changes now in progress in the animate and inanimate world.

Our opinions respecting the alternation of periods of general repose and disorder have been explained in former chapters †; and we have pointed out our objections to the hypothesis which substitutes paroxysmal violence for the reiterated recurrence of minor convulsions ‡.

The speculation of M. de Beaumont concerning the 'secular refrigeration' of the internal nucleus of the globe, considered as a cause of the instantaneous rise of mountain-chains, appears to us mysterious in the extreme, and not founded upon any induction from facts; whereas the intermittent action of subterranean volcanic heat is a known cause capable of giving rise to the elevation and subsidence of the earth's crust without interruption to the *general* repose of the habitable surface.

We have shown, in the second volume, that we believe the changes in physical geography, which are unceasingly in progress, to be among the causes which contribute, in the course of ages, to the extermination of certain species of animals and plants; but the influence of these causes is slow and, for the most part, indirect, and has no analogy with those sudden catastrophes which are introduced into the theory now under review. What have appeared to us to be the true causes of the abrupt transitions from one set of strata to another, containing distinct organic remains, have been explained at length in the third and fourth chapters of this volume §.

\* Ann. des Sci. Nat., Septembre, Novembre, et Décembre, 1829. Revue Française, No. 15, May, 1830. The last version by M. de B. which I have seen is in the Phil. Mag. and Annals, No. 58, new series, p. 241.

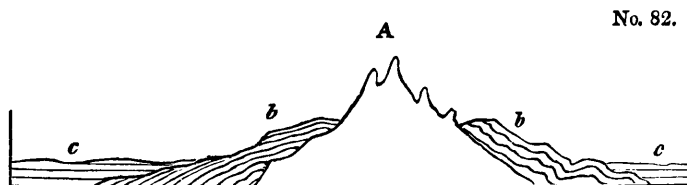
† Vol. i. pp. 64 and 88, and Second Edition, pp. 73 and 100; vol. ii. p. 196, and Second Edition, p. 203.

‡ Vol. i. p. 79, and Second Edition, p. 90.

§ See particularly from p. 26 to p. 34.

The notion of deluges accompanying the protrusion of mountain-chains is founded on a belief of the instantaneousness of the movement which we are prepared to controvert, and on other assumptions which we have discussed in a former part of this volume \*. On these topics, therefore, it will be unnecessary for us to dilate at present, and we shall merely address ourselves to the analysis of that evidence whereby M. de Beaumont endeavours to establish the successive elevation of different mountain-chains, and the supposed law of parallelism in the lines of contemporaneous elevation.

*M. de Beaumont's proofs that different chains were raised at different epochs.*—‘ We observe,’ says M. Elie de Beaumont, ‘ 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 †.’ There are, therefore, in each chain two classes of sedimentary rocks, the ancient or inclined beds, and the newer or horizontal. It is evident that the first appearance of the chain itself was an event ‘ intermediate between the period when the beds, now upraised, were deposited, and that when the strata were produced horizontally at its feet.’



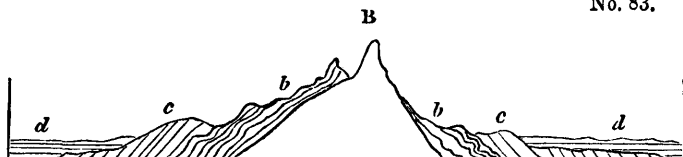
Thus the chain A received its present form after the deposition of the strata *b*, which have undergone great movements, and before the deposition of the group *c*, in which the strata have not suffered derangement.

\* See above, p. 148.

† Phil. Mag. and Annals, No. 58, new series, p. 242.

If we then discover another chain, B, in which we find not only the formation *b*, but the group *c* also, disturbed and

No. 83.



thrown on its edges, we may infer that the latter chain is of subsequent date to A; for B was elevated *after* the deposition of *c*, and before that of the group *d*; whereas A originated *before* the strata *c* were formed.

In order to ascertain whether other mountain ranges are of contemporaneous date with A and B, or whether they are referrible to *distinct* periods, we have only to inquire whether the geological phenomena are identical, namely, whether the inclined and undisturbed sets of strata correspond to those in the types above mentioned.

*Objections to M. de Beaumont's theory.*—Now all this reasoning is perfectly correct, so long as the particular groups of strata *b* and *c* are not confounded with the geological periods to which they may belong, and provided due latitude is given to the term contemporaneous; for it should be understood to allude not to a moment of time, but to the interval, whether brief or protracted, which has elapsed between two events, namely, between the accumulation of the inclined and that of the horizontal strata.

But, unfortunately, the distinct import of the terms 'formation' and 'period' has been overlooked, or not attended to by M. de Beaumont, and hence the greater part of his proofs are equivocal, and his inferences uncertain; and even if no errors had arisen from this source, the length of some of his intervals is so immense, that to affirm that all the chains raised in such intervals were *contemporaneous*, is an abuse of language.

In order to illustrate our argument, let us select the Pyrenees as an example. This range of mountains, says M. de Beaumont, rose suddenly (*à un seul jet*) to its present

elevation at a certain epoch in the earth's history, namely, between the deposition of the chalk and that of the tertiary formations; for the former are seen in vertical, curved, and distorted beds on the flanks of the chain, while the latter rest upon them in horizontal strata at its base.

The only proof offered of the extreme suddenness of the convulsion is the shortness of the time which intervened between the formation of the chalk and that of the tertiary strata. 'For it follows,' we are told, 'from the unconformable position of two systems of beds, the inclined and the horizontal, that the elevation of the former 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 formed; in a word, that it was sudden and of short duration\*.'

We are prepared to show that the Pyrenees cannot be assumed to have risen, as M. de Beaumont imagines, in the interval between the period of the chalk and that of the tertiary strata; for we can only say that the movement took place after the commencement of the chalk epoch, and before the close of the Miocene tertiary period. But, first, let us suppose the premises of our author to be correct, and let us permit him to exclude the whole period of the chalk, on one hand, and of the tertiary formations in contact with it on the other; what will then be the duration of the interval? We can only estimate its importance by ascertaining what description of chalk is found on the flanks of the Pyrenees, and what horizontal tertiary formations at their base.

Now the beds called chalk, although they differ widely in mineral composition from the white chalk with flints of England and France, contain the same species of fossil shells, and may, therefore, on that evidence, be referred to the same age †. On the other hand, the horizontal tertiary strata at the

\* Phil. Mag. and Annals, No. 58, new series, p. 243.

† The fossils which I collected in company with Captain S. E. Cook, R. N.,

western end of the Pyrenees, near Bayonne, are certainly of the Miocene period.

Such, then, being the age of the strata, and granting even that the movement occurred after the period of the white chalk, and before the beginning of the Miocene era, there still remains ample scope for conjecture as to the date of the event. For the upheaving of the Pyrenees may have been going on when the animals of the Maestricht beds flourished, or during the indefinite ages which may have elapsed between their extinction and the introduction of the Eocene tribes, or during the Eocene epoch, or between that and the Miocene. Or the rise may have been going on continuously throughout several or all of these periods.

But this is not all; we must include within the possible space of time wherein the convulsions may have happened, part of the epochs both of the chalk and of the Miocene species. We have stated, that the newer Pliocene beds in Sicily have been raised during the newer Pliocene epoch, partly, perhaps, in the Recent, but this latter supposition will lend equal support to our present argument. Now, it is evident that the greater part of the species of testacea which pre-existed in the Mediterranean have survived the elevation of the newer Pliocene beds in Sicily, and in the same manner there is no reason to conclude that the rise of the chalk in the Pyrenees exterminated the animals which lived in the sea wherein the chalk was formed. In that case, a series of convulsions may not only have begun, but may even have been completed before the era when the Maestricht beds originated.

In like manner the sea may have been inhabited by Miocene testacea for ages before the deposition of those particular Miocene strata which occur at the foot of the Pyrenees, and the disturbing forces may have operated in the Miocene period,

from the newest secondary beds on the flanks of the Pyrenees, near Bayonne, were examined by M. Deshayes, and found identical with species of the chalk near Paris.

notwithstanding the horizontality of the tertiary formations of that age.

In order to illustrate the grave objections above advanced, which are aimed at the validity of the whole of de Beaumont's reasoning, let the reader suppose, that in some country three styles of architecture had prevailed in succession, each for a period of 1000 years; first the Greek, then the Roman, and then the Gothic; and that a tremendous earthquake was known to have occurred in the same district during some part of the three periods,—a shock of such violence as to have levelled to the ground every building. If an antiquary, desirous of discovering the date of the catastrophe, should first arrive at a city where several Greek temples were lying in ruins and half engulfed in the earth, while many Gothic edifices were standing uninjured, could he determine on these data the era of the shock? Certainly not. He could merely affirm that it happened at some period after the introduction of the Greek style, and before the Gothic had fallen into disuse. Should he pretend to define the date of the convulsion with greater precision, and decide that the earthquake must have occurred in the interval between the Greek and Gothic periods, that is to say, when the Roman style was in use, the fallacy in his reasoning would be too palpable to escape detection for a moment.

Yet such is the nature of the erroneous induction which we are now exposing. For, in the example above proposed, the erection of a particular edifice is not more distinct from the period of architecture in which it may have been raised, than is the deposition of chalk, or any other set of strata, from the geological epoch to which they may belong. Yet, if on these grounds we are compelled to include in the interval in which the elevation of each chain may have happened, the periods of those two classes of formations before alluded to, the deranged and the horizontal, it follows that, even if all the facts appealed to by de Beaumont are correct, his intervals are of indefinite extent. He is not even warranted in asserting that the chain



A (p. 340) is older than B (p. 341), if he means that it was elevated at a different *geological period*, for both may have been upheaved during the same period, namely, that when the strata *c* were formed.

*Supposed parallelism of contemporaneous lines of elevation.*— So, also, when he infers that two chains were simultaneously upraised, the proof fails, since the close of the period of the disturbed strata and the commencement of the era of the undisturbed must be added to the lapse of time during which the two chains may have originated, and in separate parts of which each may have been produced. With the insufficiency of the above evidence the whole force of the argument in support of the parallelism of lines of contemporaneous movement is annihilated.

This hypothesis, indeed, of parallelism appears, even as stated by the author, in some degree at variance with itself. When certain European chains had been assumed to have been raised at the same time on the data already impugned, it was found that several of these contemporaneous chains had a parallel direction. Hence it was presumed to be a general law in geological dynamics that the chains upheaved at the same time are parallel. For example, it was said that the Pyrenees and other coetaneous chains, such as the northern Apennines, have a direction about W. N. W. and E. S. E., and to this line the Alleghanies in North America conform, as also the ghauts of Malabar, and certain chains in Egypt, Syria, northern Africa, and other countries; and from this mere conformity in direction it was presumed that all these mountain-ranges were thrown up simultaneously.

To select another example, the principal chain of the Alps, differing in age and direction from the Pyrenees, is parallel to the Sierra Morena, the Balkan, the chain of Mount Atlas, the central chain of the Caucasus, and the Himalaya. All these ridges, therefore, were probably heaved up by the same paroxysmal convulsion! The western Alps, on the other hand, rose at a still earlier period, when the parallel chains of Kiöl, in Scan-

dinavia, certain chains in Morocco, and the littoral Cordillera of Brazil, were formed!

Not only do these speculations refer to mountains never touched, as M. Boué remarks, by the hammer of the geologist, but they proceed on the supposition, that in these distant chains the geological and geographical axes always coincide. Now we know that in Europe the *strike*\* of the beds is not always parallel to the direction of the chain. As an exception, we may instance that pointed out by Von Dechen †, who states that in the Hartz the direction or *strike* of the strata of slate and greywacke is sometimes from E. and W. and frequently N. E. and S. W.; whereas the geographical direction of the mountain-chain is decidedly from E. S. E. to W. N. W.

In addition to these uncertainties, which should, in the present state of science, have deterred a geologist even from speculating on the phenomena of unexplored regions, the important admission is made by M. de Beaumont himself, that the elevating forces, whose activity must be referred to *different* epochs, have sometimes acted in Europe in *parallel* lines. 'It is worthy of remark, says that author, that the directions of three systems of mountains, namely, first, that of the Pils and the Côte d'Or; secondly, that of the Pyrenees; and thirdly, that of the islands of Corsica and Sardinia, are respectively parallel to three other systems, namely, first, that of Westmoreland and the Hunsdruck, secondly, that of the Ballons (or Vosges) and the hills of the Bocage, in Calvados; and thirdly, 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*

\* The term 'strike' has been recently adopted by some of our most eminent geologists from the German 'streich,' to signify what our miners call the 'line of bearing' of the strata. Such a term was much wanted, and as we often speak of *striking off* in a given direction, the expression seems sufficiently consistent with analogy in our language.

† Trans. of De la Beche's Geol. Manual, p. 41.

*recurrence* of the same, or nearly the same, directions of elevation\*.’

Here then we have three systems of mountains, A, B, C, which were formed at successive epochs, and have each a different direction; and we have three other systems, D, E, F, which, although they are assumed to have the same strike, as the series first mentioned (D corresponding with A, E with B, and F with C), are nevertheless declared to have been formed at different periods. On what principle, then, is the age of an Indian or transatlantic chain referred to one of these European lines rather than another? why is the age of the Alleghanies, or the ghauts of Malabar, determined by their parallelism to B rather than to E, to the Pyrenees rather than to the Ballons of the Vosges?

The substance of the last objection has been anticipated by M. Boué†, who, at the same time, disputes the accuracy of many of the *facts* appealed to by M. de Beaumont. Other errors in fact have also been pointed out by MM. Keferstein, Von Dechen, and De la Beche‡. But the incorrectness of some of these data might not have affected the validity of the general theory if it had been founded on a solid basis. In regard to the Alps, MM. Necker and Studer have informed me, that on re-examining that chain since de Beaumont’s memoirs were published, they have been unable to reconcile the phenomena there exhibited with his views relating to the strike and dip of that great chain.

Professor Sedgwick has declared his adhesion to the opinions of de Beaumont; but we are not aware that he had maturely considered them in all their bearings; and he has stated some important objections to the doctrine of ‘parallelism §.’ Among others, he has remarked, that in consequence of the spheroidal figure of the earth, different mountain-chains, running north and

\* *Phil. Mag. and Annals*, No. 58, new series, pp. 255, 256.

† *Journ. de Géologie*, tome iii. p. 338.

‡ *Geol. Manual*, p. 501, and Second Edition, p. 519.

§ *Anniv. Address to the Geol. Soc.*, Feb., 1831.

south, cannot be strictly said to be parallel, since they would, if prolonged, cross each other at the poles.

*Objections of Mr. Conybeare.*—An inquiry was proposed, in 1831, by the British Association for the Promotion of Science, ‘whether the theory of M. Elie de Beaumont, concerning the parallelism of lines of elevation of the same geological era, is agreeable to the phenomena as exhibited in Great Britain?’ Mr. Conybeare, in the first part of his report, in answer to this inquiry \*, points out many lines of *distinct* ages in England which are exactly *parallel*, and others which, according to the rules laid down by M. de Beaumont, ought to agree in age with certain continental chains, and yet do not, having an entirely *different* direction. He imagines that the general strike of the secondary strata of our island, from N. E. to S. W., has been the result, not of any violent or single convulsion, but, on the contrary, of ‘a gradual, gentle, and protracted upheaving, continued without interruption *during the whole period of the formation of all these strata.*’

The same author has also adverted to some of the difficulties attending the exact determination of the geological epochs of the elevation of each chain, especially where the disturbed and undisturbed strata in contact are not very nearly of the same age, or, as he expresses it, ‘where they are not terms immediately following one another in the regular geological series †.’ We were forcibly struck with the uncertainty arising from this cause during a late tour, when we discovered that at the eastern end of the Pyrenees, on the side of France, tertiary strata of the older Pliocene epoch abut against vertical mica-schist; while at the western extremity of the same mountain-range we find the disturbed series to consist of chalk, the undisturbed of Miocene strata. The chain is then lost in the sea, and we are precluded from pushing our investigations farther to the westward; but

\* Phil. Mag. and Journ. of Sci., No. 2, third series, p. 118. The second part, I believe, is not yet published.

† Ibid., p. 120.

if we could follow the strike of the beds in their submarine prolongation, who shall say that the *tilted* group might not be found to include strata newer than the chalk, the *horizontal* beds older than the Miocene?

*Supposed instantaneous rise of a mountain-chain.*—‘Everything shows, says M. Elie de Beaumont, 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\*.’

We observe with pleasure the rejection, by Mr. Conybeare, of the hypothesis that the disturbances affecting large geographical districts have been produced *at one blow*, rather than by a series of shocks which may have occurred at intervals through a long period of ages, and that he contends for the greater probability of successive convulsions, on the ground that such an hypothesis is most conformable to the only analogy presented by actual causes—‘the operations of volcanic forces †.’

*Modern volcanic lines not parallel.*—By that analogy we are led to suppose that the lines of convulsion, at former epochs, were far from being uniform in direction, for the trains of *active* volcanos are not parallel, as every one is aware who has studied Von Buch’s masterly survey of the general range of volcanic lines over the globe ‡, and the elevations and subsidences caused by modern earthquakes, although they may sometimes run in parallel lines within limited districts, have not been observed to have a common direction in distant and independent theatres of volcanic action.

We do not doubt that in many regions the ridges, troughs, and fissures caused by modern earthquakes, are, to a certain extent, parallel to each other, but only within a limited range of country; and such appears to have been the case in many districts at former eras. The anticlinal lines of the Weald Valley, before alluded to, and of the Isle of Wight, may, in this manner, have been contemporaneous, that is to say, both

\* Phil. Mag. and Annals, No. 58, new series, p. 243.

† Phil. Mag. and Journ. of Sci., No. 2, third series, p. 121.

‡ Physical. Besch. der Canarischen Inseln. Berlin, 1825.

may have been formed in some part of the Eocene period,—an hypothesis which does not involve the theory of their having been due to paroxysmal convulsions during one part of that vast period.

It should be observed, that as some trains of burning volcanos are parallel to each other, so at all periods some independent lines of elevation may be parallel *accidentally*, or not in obedience to any known law of parallelism; but, on the contrary, as exceptions to the general rule. We hope that the speculations of M. de Beaumont will be useful in inducing geologists to inquire how far the uniformity in the direction of the beds, in a region which has been agitated at any particular period, may extend; but we trust that travellers will not be led away with the idea that, on arriving in India, America, or New Holland, they have only to use the compass and examine the strike of the beds in order to discover the relative era of the movement by which they were upraised. Such problems can in truth be only solved by a patient and laborious investigation of the sedimentary formations occurring in each region, and especially by the study of their organic remains.

*Difficulties attending the determination of the relative age of mountains.*—If we are asked whether we cherish no expectation of fixing a chronological succession of epochs of elevation of different mountain-chains, we reply, that in the present state of our science we have no hope of making more than a loose approximation to such a result. The difficulty depends chiefly on the broken and interrupted nature of the series of sedimentary formations hitherto brought to light, which appears so imperfect that we can rarely be sure that the memorials of some great interval of time are not wanting between two groups now classed as consecutive. Another great source of ambiguity arises from the small progress which we have yet made in identifying strata in countries somewhat distant from each other.

There may be instances where the same set of strata, preserving throughout a perfect identity of mineral character, may be traced continuously from the flanks of one independent

mountain-chain to the base of another, the beds being vertical or inclined in one chain, and horizontal in the other. We might then decide with confidence, according to the method proposed by M. de Beaumont, on the relative eras when these chains had undergone disturbance; and from one point thus securely established, we might proceed to another, until we had determined the dates of many neighbouring lines of convulsion.

We fear that the cases are rare where such evidence can be obtained; and, for the most part, we can identify the age of strata, not by their continuity and homogeneous mineral character, but by organic remains. When by their aid we prove strata to be contemporaneous, we must generally speak with great latitude, merely intending that they were deposited in the same geological epoch during which certain animals and plants flourished.

---