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II.—ESSAYS IN THEORETICAL GEOLOGY.

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3. THE AGE AND ORIGIN OF THE HIMALAYAS, WITH ESPECIAL REFERENCE TO THE REV. O. FISHER'S THEORY OF MOUNTAIN FORMATION.

Introductory.

IT has become one of the truisms of geology that India, like Gaul, is divided into three parts, the Peninsular, the Extra-peninsular, and the Indo-gangetic alluvium.

Of these the first, the Peninsular, has been dry land since the Palæozoic period at least. It consists of a core of highly metamorphosed and contorted gneiss, on which are the remains of a skin of sedimentary rocks of various ages, and a vast expanse of trappean outbursts. Except in the Aravallis, the beds are but slightly disturbed, and the whole area has evidently been in a state of quiescence

throughout the greater part of the period which has elapsed since the commencement of the sedimentary period. The region seems to have undergone but little oscillation of level, and such oscillations as have taken place never brought more than the margins of the area beneath the level of the sea. With the exception of the Aravallis before mentioned, there is no structural mountain-range in the Peninsular area, and such tracts as, from their elevation, deserve the name of mountains, owe their limitations to the action of subaerial denudation.

In contrast with this the Extra-peninsular area, if we except the Upper Tertiary beds at the top of the sequence and the Archæan gneisses at the base, contains few sedimentary rocks which are not of marine origin. Almost everywhere they are intensely disturbed, and the area is essentially one of structural mountain ranges, that is, of ranges whose general direction is closely connected with, and caused by, the disturbance the beds have undergone. Of this area we are at present concerned with the Himalayas, that system of mountains which rises abruptly from the plains of Upper India, range beyond range, to the snow-clad summits forming the highest spots on the surface of the Earth.

In the contour of the two areas there is a vast difference. The surface of the Peninsular area shows rounded outlying and gentle slopes, except where the outcrop of hard or massive beds has led to the formation of scarps; the gradients of the streams are flat, their beds sandy, and seldom do they show signs of active erosion of their channels; in fact, the Peninsular area shows all the features of an ancient land-surface, long exposed to subaerial denudation, in which the streams and hill-slopes have alike gone far towards reaching a condition of equilibrium.

The Himalayas, on the contrary, are a region of deep, steep-sided, valleys and gorges; nearly everywhere the streams and rivers alike are torrents flowing over a bed of coarse boulders, everywhere, with but local exceptions, they are evidently eroding their channels, while the steep slopes and sharp crests of the ridges, no less than the constant landslips and general instability of the soil, betoken a country in which the action of rain and frosts on the hill-sides has not been able to keep pace with the deepening of the stream-beds by erosion.

Equally striking is the contrast in the nature of the boundary of the two areas with the Indo-gangetic alluvium. To the north the Himalayas rise abruptly from slopes of recent gravels at their base, and, though there are irregularities of detail, the boundary as a whole sweeps in a crescent curve from one extremity to the other, while there are no outliers of the Himalayan beds surrounded by alluvium, nor are there any long tongues of the latter running up into the Himalayan area. To the south the rocks slip imperceptibly under the alluvium, so much so that different observers have differed by miles in the boundary they drew between the alluvium and the older rock; the boundary exhibits every variety of irregularity, long tongues of alluvium run up the various river valleys far into

the rock area, and, to crown all, there are outliers innumerable of the peninsular rocks standing up from the alluvial plain.

These last contrasts between the two areas are shown even on a good topographical map; but that now to be mentioned, the most important of all, can only be seen on one that is geologically coloured.

Along its southern boundary the alluvium is in contact with rocks of various ages; but to the north, with the exception of a short distance in Sikkim, a zone of rocks of Tertiary age separates the alluvium on the one hand from the pre-Tertiary rocks of the Himalayas on the other. In a word, the southern boundary is due to the freaks of denudation and alteration of level, while the northern is a structural boundary; and this will be made still more evident when we come to consider in more detail that band of Tertiary deposits which forms the southern margin of the Himalayas, and has so important a bearing on the subject with which this paper deals.

Part I. The Facts.

The Tertiaries of the outer Himalayas present a marked similarity of type along the whole extent of the range, but the sequence is not everywhere equally complete. In the extreme north-west there is a great series of beds, ranging from the marine Nummulitics at the base to the subaerially deposited Pliocene conglomerate sandstones and clays at the summit. They were divided by Mr. Wynne, who examined this country, as follows:¹—

1. Upper Siwalik, about 4000 feet; brown drab or reddish clays, soft grey sandstones, conglomerates.
2. Lower Siwalik, about 10,000 feet; soft grey sandstones and brown and grey clays, many red clays.
3. Murree beds, average 7500 feet; harder grey sandstones with soft zones, red or purple clays.
4. Nummulitic, upper 800 feet; greenish grey and purple sandstones, grey, olive-brownish, red and variegated clays with masses of gypsum.
5. Nummulitic limestones with shales and coal at base.

The series is said to be parallel and conformable from the pale limestones upwards to the top of the Siwaliks.

The series in the Jamu² (Jummoo) hills appears to be practically the same, except that the Nummulitic Limestone is much less developed.

In the Simla region the Tertiaries are divided into two distinct areas, in which the beds are of different ages, though they may slightly overlap each other. The first area forms part of the lower Himalayas and the beds constitute the so-called Sirmur series, divided into

1. The Kasaoli group; grey sandstones, sandy shales, and shales containing plant-remains.
2. The Dagshai group; hard, fine-grained sandstones and red or purple nodular shales, the former prevailing in the upper and the latter in the lower part of the group.

¹ Records Geol. Surv. India, vol. x. p. 112 (1877).

² Mem. Geol. Surv. India, vol. xxii. chap. v. (1883).

3. The Subathu group; olive green, grey and red shales and subsidiary bands of sandstone and argillaceous limestone, with a coal-seam and a peculiar ferruginous bed at the base. It contains Nummulites and other marine fossils.

The second area, forming part of the sub-Himalayas, is divided from the Sirmur series by a great fault, and, in many places, by a narrow strip of pre-Tertiary beds; the series may be divided as follows:

1. Upper Siwalik; soft sandstones or sandrock, conglomerates and some clays.
2. Lower Siwalik; soft sandstones or occasionally pebbly sandstones, and clays mostly grey, but sometimes tinged with red, especially in the lower part of the group.
3. Nahan group; firm or hard sandstones interbedded with clays generally nodular and of a bright red colour, which are more abundant in the lower part of the group than in the upper.¹

The series in the two areas combined appears to be much the same as in the Murree hills. The Nummulitic Limestone is not developed, and the marine deposits are much less in thickness; but there can be no doubt that the Subathu group represents the Nummulitic groups of Mr. Wynne. The Dagshai and Murree groups correspond so closely in mineral character and stratigraphical position that there can be no risk of error in correlating them, while the two upper groups in the north-west are evidently the equivalents of the three groups in the sub-Himalayas of the Simla region and possibly in part of the Kasaoli group of the Sirmur series.

To the east of the Ganges there are a few small outliers of the Subathu group faulted and folded among the pre-Tertiary beds near their southern boundary; but with this exception the only Tertiary beds known here or to the eastwards are confined to the Nahan and Siwalik groups.²

Besides these Tertiaries of the Outer Himalayas, beds of the same age are known to exist at several places to the north of the main snowy range; but it is only in Cashmere territory that they have been examined in any detail. In the Upper Indus Valley the Nummulitics may be briefly described as consisting, at the base, of coarse-grained sandstones, arkose beds and conglomerates, considered by Mr. Lydekker to be of glacial origin; they are certainly of littoral origin, and indicate the close proximity of the original limit of deposition. Above these come red, and green and grey shales, of very similar type to those of the Subathu group, interbedded with limestones; while at the top the series consists of a great thickness of beds, mainly volcanic in their origin and basic or ultrabasic in composition.³

The coarse-grained beds of littoral origin are confined to the north-eastern boundary of the exposure, whose south-western boundary is marked by great disturbance, and is in effect a faulted one. It seems then that to the north-east the original limit of deposition was not far removed from the present boundary, but

¹ Comp. Medlicott, *Mem. Geol. Surv. India*, vol. iii. part 2, chaps. i. and iii.; also *Manual of Geology of India*, vol. ii. chap. xxii.

² Oldham, *Rec. Geol. Surv. India*, vol. xvii. p. 161 (1884); Middlemiss, *Mem. Geol. Surv. India*, vol. xxiv. part. ii. 1890.

³ *Mem. Geol. Surv. India*, vol. xxii. chap. v.

to the south-west there is no indication of the original limit of deposition; and the small outlier in the Singhe La, between Zaskar and the Indus Valley, is described by Mr. La Touche as consisting of a fœtid limestone, resting directly on the Secondary quartzites without the intervention of any beds of a littoral or shallow-water origin.¹ From this it is evident that the land-surface must have been far to the southwards, and it may be that the sea extended over the whole of the Himalayan area between this and the outcrops of the Subathu group, as it certainly must have done over a considerable portion of it.

Having briefly reviewed the geology of the Himalayas so far as is necessary to make what follows intelligible, we must now enter into a detailed consideration of the evidence. It is not, however, intended to give here anything resembling a complete account of the geology of the Himalayas, for such would be impossible in the space available, but merely to notice such points as have a special connection with the age and elevation of the Himalayas.

The first, most important, most palpable and unmistakeable point that stands out is that, at the commencement of the Tertiary period, the Himalayas did not exist as a distinct mountain range, or at least that, if the Himalayan system of disturbance had commenced, it had not extended north-west of a line, drawn transverse to the range, through the debouchure of the Ganges. This is amply proved by the occurrence of marine nummulitics in the heart of the Himalayas, in the Upper Indus Valley and in Zaskar, at heights of 19,000 to 20,000 feet above the level of the sea.

But besides this the nature of the contact between the Nummulitic and pre-Tertiary beds points to the same conclusion. In the Upper Indus Valley the Nummulitics rest directly on an eroded surface of, presumably, Archæan gneiss; in the outer hills, however, they rest on limestones or slates, and Mr. Medlicott has noticed how, both near Subathu and in the Jamu Hills,² wherever the boundary is one of original contact, there is no perceptible divergence of dip between the Tertiary and pre-Tertiary formations. The same appears to be the case with the outliers in Garhwal, and this shows that, though the older rocks had been denuded before the Nummulitics were deposited, they had not at that time been seriously disturbed, and that their position was practically one of horizontality.

It is true that, in his recently published memoir, my colleague, Mr. Middlemiss, has shown good reason for believing that, at the commencement of the Tertiary period, the pre-Tertiary beds were not everywhere so slightly disturbed as the contact with the Nummulitics would indicate.³ But the Himalayan area is a large one, and it would be unnatural to suppose that there had been no disturbance of any part of it before the commencement of the Tertiary period; while the evidence produced by Mr. Middlemiss

¹ *Rec. Geol. Surv. India*, vol. xxi. p. 161.

² *Rec. Geol. Surv. Ind.* vol. ix. p. 54.

³ *Mem. Geol. Surv. Ind.* vol. xxiv. p. 184.

shows that the pre-Tertiary disturbance was transverse, and did not belong to that which has resulted in the elevation of the Himalayas. It may be that in Kumaon and Garhwal this last had already commenced when the Nummulitics were being deposited and only extended to the north-west at a later period; but there is no evidence to show that it could have commenced before the end of the Secondary period; and the early Palæozoic or still earlier date, to which Mr. Middlemiss would seem inclined to refer the first origin of the Himalayas as a mountain range, is, to say the least, extremely improbable.

Besides the stratigraphical evidence of the absence of disturbance, there is everywhere, from the Jamu Hills to the outliers east of the Ganges, a peculiar pisolitic, ferruginous bed, which invariably occurs at the base of the Subathu group. In mineral and chemical character this closely resembles the laterite of the Peninsula and the laterite beds, which occur interbedded with the Nummulitics of Cutch and Sind, and must probably be referred to the same source of origin. The origin of the laterite of the Peninsula is still a vexed question, which has been much complicated by the very loose manner in which the term has been used; but the balance of evidence seems to show that the true laterite is in some way or other connected with the Deccan Traps, and is directly or indirectly the result of an alteration of them or their detritus. If this same source of origin is accepted for the ferruginous bed at the base of the Subathu group, it follows that the present distinction between Peninsular and Extra-peninsular areas had not been established in Eocene times, and, consequently, that the system of disturbance of which it is the result must, at the outside, only have commenced when the Subathu group was being deposited.

In this connection the occurrence of Gondwana rocks of Peninsular type in Sikkim and the Eastern Himalayas is important. Unfortunately nothing is known of the great area of Nepaul, which occupies the middle third of the length of the Himalayas; but Sikkim cannot in any way be regarded as a terminal area, and the occurrence of Peninsular beds of latest Palæozoic or early Secondary age¹ shows that the present limits between the Peninsular and Himalayan areas cannot have been established until the Secondary period at the earliest.

A further insight into the history of the commencement and progress of the elevation of the Himalayas may be derived from a study of the structure of the sub-Himalayan ranges.

In the region west of the Jhelum the structure of the ground does not enable us to decide with certainty at what date the Himalayan system of disturbance invaded that area; but, so far as can be judged, the beds appear to have undergone but little compression till towards the end of the Tertiary period.

In the Jamu Hills we find the typical sub-Himalayan structure

¹ Mallet, *Mem. Geol. Surv. India*, vol. xi. part i.; see also Godwin-Austen, *Journ. Asiatic Soc. Bengal*, part ii. vol. xxxviii. p. 151; La Touche, *Records Geol. Surv. India*, vol. xviii. p. 121.

has commenced, though not so fully developed as further to the south-east. Next to the pre-Tertiary rocks of the Himalayas proper comes a broad zone, principally formed of the Murree group, at the outer margin of which rise some inliers of pre-Tertiary (Carboniferous?) limestone, overlaid by the marine Subathu group, while near the inner boundary, with the pre-Tertiary rocks, there are some outliers of Upper Siwalik clays and conglomerates. The general section from S.W. to N.E. is therefore an ascending one, and both boundaries of this zone are, in effect, great faults with an upthrow on the Himalayan side. Between this zone of Murree beds and the alluvium of the plains there comes a band of Upper Tertiaries, which, on the only published maps, are divided into an inner, older, and an outer, newer zone; but there is no indication of the nature of the boundary.

After leaving the Jamu Hills, the zone of Lower Tertiaries becomes much restricted in width, till we reach the Simla region. Here the Lower Tertiaries, forming the Sirmur series, are distinctly separated from the Upper Tertiaries or Nahan and Siwalik groups. The boundary is a great reversed fault, and along nearly the whole length of it the two divisions are not in contact, but separated by a band of pre-Tertiary slates and limestones. The beds of the Sirmur series have partaken of the intense disturbance of the pre-Tertiary beds, with which they are folded up in the most complicated manner, and the northern boundary is no longer a single well-defined fault, to the north of which there are no outliers. But the most important point to notice is that in the area occupied by the Sirmur series there is no trace of the Upper Tertiary groups, which were either never deposited or have been completely removed by denudation.

Still further to the south-east, the small outliers in Garhwal only exhibit the remains of the Subathu group, no representative of the two Upper groups of the Sirmur series being found.

The explanation of these facts, which has been adopted by every observer of the ground in question, is that the disturbance of the Himalayas gradually advanced from S.E. to N.W., and that the missing upper groups were never deposited over the outliers owing to the elevation resulting from this disturbance. There is ample corroborative evidence to prove the truth of this hypothesis; but the same result is arrived at even if we suppose that the full sequence of deposits was formed everywhere alike, for the condition of the Simla area is such as would result from a greater elevation and denudation of the Jamu area, while the outliers in Garhwal might result from a still further extension of the same processes. But as both elevation and denudation take time, and as the conditions of the three areas with regard to denudation at least are substantially similar, we reach the same conclusion as before, that the elevation, and consequently the denudation of the Garhwal area must have commenced before that of the Simla area, and this again before that of the Jamu Hills.

Before passing on to a consideration of the evidence of the

Siwalik groups, it will be well to briefly examine the nature and distribution of the deposits now being formed along the foot of the Himalayas. Along the outer margin of the hills there is everywhere a zone of gravel and boulder deposits; near the debouchure of the great rivers this consists of well-rounded fragments of crystalline rocks, quartzite, and some limestone; where there are no large rivers, the fragments are less rounded, and consist of the rocks exposed within the drainage-area of the streams flowing down from the hills. The similarity of these gravels to those brought down at the present day, and the fact that their diversity is matched by that of the gravels of the existing streams, leaves no room for doubt that they deposited the gravels even in those districts where they have since cut deep channels through their old deposits.

Outside the zone of boulders and gravel comes a region of sands, of various degrees of fineness, and outside this again the clays and fine silts which form the bulk of the Gangetic alluvium.

It must not be understood that this division into three zones is absolute. Sand and clay are occasionally found close up to the foot of the hills, even near the debouchures of the great rivers, but none the less it truly represents the general disposition of the recent deposits. The width of the zones is not constant, and the boulder and gravel zone in particular expands opposite the debouchures of the great rivers. With all these local variations the main fact remains, that on any line drawn transverse to the boundary of hill and plain, the deposits, omitting minor variations and local exceptions, decrease in coarseness as we pass away from the hills, that the coarse deposits of gravel and boulders are confined to the immediate neighbourhood of the boundary, and that it is only near the debouchure of the principal rivers that these are composed of large and well-rounded fragments of hard crystalline and metamorphic rocks.¹

Returning now to the Siwalik deposits, we find that the same relation between the composition of the gravels and the existing drainage system which is exhibited by the recent deposits of the northern margin of the plains, has also been noticed by every observer in the conglomerates of Upper Siwalik age.

In the neighbourhood of the Jumna and Ganges rivers we find a great development of conglomerates, composed of well-rounded boulders of crystalline and metamorphic rocks. East of the Ganges, there comes a tract where the watershed is only a few miles removed from the edge of the hills, and coincident with this there is a narrowing of the Siwalik zone, and a cessation of the thick deposits of sandstone and conglomerate, till the Ramganga and Kosi rivers are reached. Here the Siwalik beds again attain a great width and thickness, and there is a large development of conglomerates.²

In the country between the Ganges and the Jumna the conglomerates are largely developed and extend for some little distance

¹ Boulder gravels composed of well-rounded blocks of hard rock are also found in the beds of streams draining from the Upper Siwalik conglomerates; but such exceptions are obvious.

² Middlemiss, *Mem. Geol. Surv. India*, vol. xxiv. pt. 2.

west of the Jumna : but further west, in the country south of Nahan, the conglomerates not only decrease in thickness, but change their character. The well-rounded boulders of crystalline rocks cease, and, in their place, we find imperfectly rounded fragments of limestone, slate, and quartzite derived from the Lower Himalayas, mixed with a large proportion of fragments of Lower Tertiary sandstones.

Where the Sutlej passes out through the Siwalik area, there is again a large development of Upper Siwalik conglomerates and the same features of a prevalence of conglomerates near the great rivers, and their absence away from them, continues all the way to the Jhelum.¹

This peculiarity in the distribution of the Siwalik conglomerates shows that not only are the Siwalik beds of subaerial origin ; but that, when they were formed, the Himalayas existed as an elevated region whose main features of hydrography had already been marked out, and further the occurrence of coarse conglomerates, which could only have been deposited in the immediate neighbourhood of the limit of hill and plain, shows that the southern margin of the former must at that time have been approximately the same as the present boundary between the rocks of the Himalayas and of the Siwalik series.

Taking all these considerations into account, the conclusion becomes inevitable that the Siwalik beds were deposited subaerially and under conditions similar to those of the recent deposits along the foot of the Himalayas ; that the latter existed as a mountain range, comparable to that now existing, in which the main features of its hydrography had already been marked out ; and consequently that the original northerly extension of the Siwaliks cannot have very far overstepped their present northern boundary.

The thickness of these subaerially formed beds varies considerably, but is always great ; from ten to twenty thousand feet and perhaps more in places ; and as they now, after having been compressed, disturbed and elevated, do not occur at a height of more than a few thousand feet above the sea, it is evident that they must have been deposited in an area of continuous subsidence, which approximately kept pace with the deposition. On the other hand, the Himalayan area, as I shall subsequently show, has been in a state of continuous elevation throughout the Tertiary period, and this elevation has more than kept pace with the denudation of the surface. We have consequently two parallel regions, one of elevation accompanied by denudation ; the other of deposition accompanied by subsidence, and we will now investigate the nature of the boundary between them.

Everywhere along the Himalayas the present boundary, between the Upper Tertiary beds and those of pre-Tertiary age, is a gigantic reversed fault. It is one of the most conspicuous structural features of the Himalayas, and, except for the outliers of Lower Tertiary beds in the Simla district and in Garhwal, and the inliers of pre-Tertiary rocks in Jamu, forms an absolute line of demarcation between

¹ Medlicott, *Rec. Geol. Surv. India*, vol. ix. p. 57.

the Tertiary and pre-Tertiary formations. In Mr. Medlicott's memoir this great fault was called the "main boundary"—a name which has been found so convenient that it has frequently since been used in the publications of the Geological Survey of India, and will be retained here in the sense indicated above.

This main boundary fault is almost everywhere a clean cut fracture, generally reversed, and as a rule the rocks on either side show little or no signs of that crushing which one would expect to have accompanied so great a displacement. As we have seen, it marks, approximately at least, the limit between what was, in Siwalik times, an area of subsidence and an area of elevation, and it is not unreasonable, on this ground alone, to suppose that it was the actual boundary, and formed *pari passu* with the deposition of the beds to the south.

But the main boundary is not the only fault of its kind, though the most remarkable; for, both in the Himalayan and sub-Himalayan areas, there are similar great faults with an upthrow on the Himalayan side, which have been held to mark successive stages in that southerly advance of the margin of the hills, which is sufficiently proved by the elevation of the Siwalik beds, originally deposited in the plains along the foot of the Himalayas.

This supposition derives considerable support from a consideration of the nature of the boundary between the disturbed Upper Siwaliks and the recent deposits of the plains. With a few exceptions where uppermost Siwalik conglomerates dip towards and under the recent gravels, the boundary is a well-defined one, and the undisturbed recent gravels are in contact with disturbed sandstones from which several thousand feet of overlying strata have been removed by denudation. There are no great irregularities of the boundary or deep embayments of the recent deposits, such as would result from a subsidence of the hills and an encroachment of the recent deposits, such, in fact, as are seen on the southern margin of the alluvium. The beds of which the hills are formed are precisely similar in character, and were deposited under circumstances identical with those of the present submontane deposits; and this, taken in conjunction with the outline of the boundary, leads one naturally to the conclusion that the latter is a structural one, and that the hills have slowly and contemporaneously been undergoing elevation and denudation. At the same time the greater bulk of the *débris* washed down from them has been deposited near their foot, and, to make room for this vast quantity of *débris*, the latter area must have been slowly subsiding. We have consequently, in close contiguity with each other, an area which has been subject to elevation, and one which has been subject to depression, the boundary between the two being necessarily analogous to those faults with an upthrow to the north which intersect the sub-Himalayan region, and to the great boundary fault which limits it on the north.¹

¹ This question is more fully treated by my colleague, Mr. Middlemiss, in his recently published memoir, *Mem. Geol. Surv. Ind.* vol. xxiv. pt. ii.

In all the sections of the sub-Himalayan beds there is a marked and steady increase in coarseness of texture as we ascend the section. This feature is everywhere observable in the sub-Himalayan sections, and even in the Sirmur series of the Simla Hills there is a steady increase in the proportion of sand to shale from the purely argillaceous Subathu group to the chiefly arenaceous Kasaoli group. This gradual upward increase in coarseness of texture on any one section is an inevitable result of the gradual southward extension of the hill area; for by it the region of fine-grained silts is brought within reach of the sand, and, finally, of the shingle deposits. But besides the increase in coarseness of texture on each section, it is an indubitable fact that the texture of the coarsest beds of each group or division increases with its decrease in age, and this appears to me to be due to a gradual increase in the average size of the debris brought down by the Himalayan streams.

I have already shown that in Eocene times the North-West Himalayas did not exist, and that in Siwalik-Pliocene times there was a mountain range whose hydrography agreed with that of the present day in its main features, and that, to judge by the nature of the burden carried by the rivers, this range must have been comparable in elevation and extent to the present Himalayas. During the Tertiary period, then, the Himalayas were in process of elevation, and it is natural to suppose that, during the earlier part of this process, the gradients of the streams and their powers of transportation would be less than at a later period, and that, consequently, no great deposits of coarse gravel could be found. This supposition derives great support from the fact that throughout the great thickness of the Dagshai and Kasaoli groups, and of the Murree group, not a single pebble has been found, while with one very doubtful exception¹ no conglomerates of Nahan age are known.

In the foregoing passages it has been tacitly assumed that elevation has always been accompanied and caused by disturbance of the beds elevated, and such, in the main, is the case. There are, however, recent undisturbed gravels which rise, in the sub-Himalayan region, to heights of 500 feet above the present river-beds and seem to indicate that there has been a certain amount of elevation unaccompanied by disturbance of the horizontality of the beds elevated. So, too, the fossiliferous Pleistocene deposits of Hundes have probably been elevated without disturbance to some extent, though not so much as was supposed by the earlier observers.² With these subsidiary exceptions, which do not affect the general principle, it is true that, in the Himalayas, elevation has always been a result of the compression and disturbance of the beds elevated.

¹ Mem. Geol. Survey India, vol. iii. part ii. p. 135.

² Lydekker, Rec. Geol. Survey of India, vol. xiv. pp. 178-183 (1881).

(To be continued.)