Report *on the* Geology *of* Thal Chotiáli *and part of the* Mari country, *by* R. D. OLDHAM, A.R.S.M., F.G.S., *Deputy Superintendent, Geological Survey of India.* (With a map and 5 plates.)

Area to be described.

The area to be described in the following paper lies to the east of that treated of last year; its limits can be seen by reference to the map annexed.

Previous literature.

Apart from the very brief mention of the gorge at Tung by Dr. Blanford,[1] and some papers regarding the petroleum at Khattan which have been referred to in my previous report,[2] there is no literature regarding the area under description.

Structure. Absence of great faults.

The structure presents the same features as were noticed before, in the almost complete absence of any of those great reversed faults and thrust planes which are so common in mountain regions. The only exception is in the south-east corner, where, according to Sub-Assistant Hira Lal, the upper nummulitic beds and cretaceous beds are faulted into direct contact with each other. But, though not exhibited on a large scale, there are many very pretty instances of faults on a small scale, two of which are shown in Plates I and II.

Horizontal beds.

A very remarkable occurrence of horizontal beds over a considerable area in the Béji valley was quite unexpected in a region usually so highly disturbed. The horizontality is made very conspicuous in the field, and easily recognizable on the map, by the capping of hard Spintangi limestones crowning the hills of Gházij shales and exhibiting those long horizontal lines of cliff and talus slopes, with an irregular outline cut by numerous re-entering angles, which form the scenery characteristic of a deeply eroded series of horizontal beds of unequal hardness.

Stratigraphy. Oldest rock seen: massive limestone.

The oldest rock exposed is the same grey limestone as was seen in the Miráb Tangi,[3] but it was much better seen this year in the hills west of the Thal Chotiali plain, which are traversed by the Sémbar pass. The beds are thrown into an anticlinal fold, whose core, composed of these hard grey limestones, stands up as a high hill, traversed by the deep gorge of the Sémbar pass.

This gorge is not of the ordinary type of water-worn ravine, exhibiting on either side a section of the beds through which it is cut, but has been formed along a deep and sharply-folded synclinal flexture, which obliquely traverses the main anticlinal. The stream has taken advantage of the narrow strip of soft beds, which was thus made to traverse the hard limestone core, and has deprived us of the deep cut section which this pass should otherwise have exhibited.

About 3 miles to the west, however, there is a gorge cut through a lower part of the hill which exposes a section of a portion of the limestone, and exhibits it as very similar in type to the cretaceous grey limestones of the Quetta hills, with which I have little doubt that it is identical.

[1] Mem., Geol. Surv., Ind., XX, p. 197.

[2] Rec., Geol. Surv., Ind., XXII, p. 93.

[3] Rec. Geol. Surv. Ind., XXII, p. 93; the word 'nummulitic' in the marginal reference is an error.

This limestone crops out in the centre of the Dunghan mountain, of the anticlinals of Samach, of the Miri hill, and of Mazár Drik in the Béji valley. Though not mapped as occurring in the Rastaráni hill, east of Mámand, it appears to occur there, so far as can be judged from the account of Sub-Assistant Hira Lal.

Distribution.

From none of these last named localities were any fossils obtained, but in the Sémbar pass the uppermost beds yielded some fossils, among which a *Rhynconella* was most abundant. A fragment of an ammonite was also found, and *Belemnites*, which appeared to belong to the same species as occurred in the next succeeding group, but they had been shattered by the disturbance the beds had undergone, and could only be extracted in a fragmentary condition which precludes any specific determination.

Fossils.

The massive cretaceous limestones are overlaid with perfect conformity by a series of beds which, in the Sémbar pass, attains a thickness of at least 1,000 feet, but is usually much thinner, the difference being apparently due principally to a squeezing out of the lower shaly beds by compression. In the Sémbar pass the lower half of the group is composed of black shales with some sandy and calcareous beds and, near their base, the shales contain an admixture of volcanic ash. The upper half of the group consists of distinctly bedded green and purple indurated marls and limestones, capped by about 250 feet of compact white limestone.

Belemnite beds.

These upper beds resemble so closely, in lithological character, those variegated beds seen in the Chappar rift, which were formerly[1] referred to by me as the Chappar shales, that I have no hesitation in identifying the two. They agree, moreover, in stratigraphical position, as will be seen further on, and the occurrence of an admixture of volcanic ash with the sedimentary material of the lower beds in the Tarai Tangi[2] is another fact pointing to the same conclusion; moreover, there are frequent exposures of precisely similar beds occupying the same position relative to the other rock groups in the ground intervening between the Sembar pass and the Chappar rift.

Equivalent to Chappar shales.

Having established the identity of the group in the two separate localities, it appears inconvenient that it should retain a name derived from a locality where it is very imperfectly exposed, neither the thick white limestone at the top, nor the still thicker black shales at the base being represented, except in a most imperfect manner, and I shall in future refer to the group as the 'belemnite beds.'

These belemnite beds are, in many places, abundantly fossiliferous, but the fossils found are almost entirely confined to several species of *Belemnites*, mostly belonging to the section *Dilatati*, the only exceptions being a few fragmentary casts of *Ammonites* found 3 miles west of the Sembar pass.

Fossils, belemnites, ammonites.

The uppermost white limestone was not observed to be fossiliferous within the area of the map, except for a few belemnites near its base, but I have seen it, on the road from Harnai to Loralai, containing both *Nummulina* and *Alveolina*. At the time I was not aware of the true stratigraphical relations of the rock, and, being inclined to class it with the overlying

Nummulites.

[1] Rec., Geol. Surv., Ind., XXIII, 93 (1890).

[2] *loc. cit.*, p. 94.

Dunghan limestone, then regarded as nummulitic, did not attach the importance to the observation which it has since proved to possess, and, unfortunately, did not carry off any specimens. There can, however, be no doubt as to the accuracy of the observation.

Distribution.

The distribution of the belemnite beds is wider than that of the underlying massive limestone. Besides forming an oval round all the exposures of the latter, it is the lowest rock exposed in the Sonári anticlinal and in two others in the south-east corner of the map; to the north of Lat. 30° it is the lowest rock seen in the cores of the anticlinals; and is known to be largely exposed to the north of the map in the direction of the Bóri valley.

The distribution of fossils in this group appears, at first sight, to be capricious, for they have only been found in the Sémbar, Samach, Mazár Drik, Dunghan and Miri anticlinals, and not in those to the north-west or south-east of these. This is, however, probably due to the fact that, in those exposures where no fossils have been found, only the uppermost beds are exposed, and these are everywhere very sparingly fossiliferous, if fossiliferous at all. Further to the north, along the Bóri-Mékhtar road, belemnites are common enough in the beds of this group.

Unconformable break.

The belemnite beds form the uppermost member of a conformable system, above which comes a slight, but distinct, unconformable break. This is best seen in the Sonári anticlinal and that near Mazár Drik in the Béji valley, where the beds immediately overlying the white limestone contain numerous fragments of it; in the Mazár Drik anticlinal the white limestone is worn into an undulating surface, on which the lowest bed of the next succeeding system is deposited, and in the upper Béji valley there is a marine conglomerate bed containing fragments of white and grey limestone, the latter being apparently derived from the massive cretaceous limestone. This unconformity is also indicated by the remarkable variations in the thickness of the white limestone, variations which are equally noticeable outside the limits of the area under description. As has already been remarked, it has a thickness of about 250 feet in the Sémbar pass, but on north side of the Mazár Drik anticlinal this is reduced to only 20 to 30 feet. So, too, on the road from Harnai to Loralai there is no distinct band of white limestone seen in the first anticlinal crossed by the Miráb-Tangi, between Harnai and Tarwe Khan, but, at Dilkúna, only 5 miles further on, the white limestone is well developed, though the thickness was not estimated.

Another fact, pointing to an unconformity between the belemnite beds and those overlying them, is the occurrence of pebbles of white nummuliferous limestone, evidently derived from the uppermost white limestone of the belemnite beds, in a conglomerate which occurs near the top of the Gházij group both near Shahrig and to the south-east of Quetta.

Unaccompanied by disturbance.

But, although this unconformity is distinct and unmistakeable, there is not, so far as I have yet seen, any recognizable divergence from a perfect parallelism of dip between the beds above and below it. It was not, consequently, preceded by any marked disturbance of the beds already formed, and need not represent very great lapse of time. On the other hand, if the identification of the pebbles of grey limestone in the lower beds of the next succeeding system with the massive cretaceous grey limestone is correct, there must have been a very extensive denudation, meaning a

considerable lapse of time, and the absence of any of the *Belemnites*, so abundant immediately below the unconformity, in the overlying beds points to the same conclusion. For the present, however, and until the results of more extended survey are available, it is impossible to determine the exact stratigraphical value of this unconformity.

Dunghan group.

The group which is met with immediately above this unconformity is, in many ways, the most interesting of all those met with; it is the same that was described by me as the Dunghan group. In the northern part of the area surveyed during the past season it presents the same character as it has in the Harnai district, that is to say, it is essentially a limestone group of great thickness. To the south a remarkable change comes in by the development of argillaceous beds in the base of the group, which encroach more and more on the limestone till, in the south-east, only a few of the uppermost beds remain as limestone, the rest of the group being mainly argillaceous with some subsidiary beds of sandstone and impure limestone. The limit of the change between the two facies is tolerably well defined, coinciding approximately with the road from Spintangi to Thal Chotiáli; and its abruptness is noteworthy. Thus, in the Dunghan mountain, the group is composed of limestones, some 2,000 feet in thickness, but within 15 miles to the east, in the Mazár Drik anticlinal and to the south-east in Sonári, there is not more than two or three hundred feet of limestone at the top of a thick series of shales.

Change of facies.

It is natural to ask whether such a sudden change of facies does not indicate a distinction between the two; such at first was the interpretation I was inclined to put upon it, and in the field maps the distinction was preserved to the last. A gradually increasing intimacy with their mode of occurrence, and a careful review of the evidence, has, however, convinced me that they are identical, in spite of their lithological dissimilarity.

Dés valley.

A very good exposure of the argillaceous facies of this group is seen in the Dés valley near Khattan. In the lower portion of this tributary valley the Gházij shales are seen, which continue till a sheer sloping face is met with, composed of the pseudo conglomerate or true limestone breccia,[1] associated with flaggy limestone as at Khattan, the total thickness being about 100 to 150 feet. This is underlaid by 600 to 700 feet of grey shales, below which comes a group of beds which forms a well marked and easily recognizable horizon in all the sections of this district. The uppermost bed is a limestone, composed almost entirely of oysters (*Exogyra ?*), but also containing a few other fossils. In the section it is very dark coloured and impregnated with petroleum, which oozes from the exposed surface. This is underlaid by sandy beds, one band of which is red throughout, and the others frequently stained red with iron. Below the sandstones, in the Dés valley, comes a great thickness, probably over 1,000 feet, of shales, many beds of which are so abundantly fossiliferous as to become impure limestones. At the head of the valley, where the dip flattens down horizontal, they form cliffs surrounding an amphitheatre, and are conformably underlaid by unfossiliferous grey, green, and purplish shales. The limit between the profusely fossiliferous beds and those in which no fossils can be found is abrupt, but perfectly conformable, and

[1] Rec., Geol. Surv., Ind. XXIII, pp. 94, 95.

though no fossils are as a rule to be found in the shales, yet, in the Mazár Drik anticlinal, I found, low down in this portion of the group, a band of *Nummulites*, apparently identical with some of the forms found higher up.

The band of sandstones, stained with iron, and overlying oyster bed, can be recognized in all the sections in the southern part of the area included in the map and is important in the identification of this shaly group with the Dunghan limestone, for, in the Mazár Drik anticlinal, the whole thickness of the beds above it consists of limestones, which there is no difficulty in recognizing as the same as the unmistakeable Dunghan limestone close by. But the identification of the shaly group with the Dunghan depends mainly on the similarity of stratigraphical position of the two and the constant presence of the pseudo conglomerate, or limestone breccia, at the top of the group marking division from the overlying Gházij shales.

This bed forms well-marked and easily recognizable horizon throughout the area surveyed; it is almost invariably visible, where the Dunghan group is shaly in composition with only a small thickness of limestone at the top, and is frequently visible in the northern part of the area, where the group is composed of limestone throughout. How far its local absence may be due to imperfect action of the causes which led to the concretionary structure being developed, and how far to imperfect exposures of the bed, it is not altogether possible to say, but it is noteworthy that, in the northern portion of the area under description, the concretionary structure is less well-developed, and here the observed occurrences are least frequent, while in the south and east, where there is hardly a contact section in which it cannot be detected, the concretionary structure is so well developed that it is frequently almost impossible to believe that it is not a true conglomerate. I have, however, no reason for departing from the conclusion come to last year regarding the nature of this structure, and, in spite of the very striking appearance presented by individual exposures, there are several features in its mode of occurrence which are incompatible with the supposition that it is a true conglomerate; these are, the absence of any important variations in thickness, its interstratification with fine grained flaggy limestones, the absence of any coarse grained deposits associated with it, and, above all, the absence of any rock, of older date, similar to that of which the "pebbles" are formed.

The presence of this peculiar and easily recognizable rock at a definite horizon has been a most important aid to the geological mapping of the country, as it enabled the boundary between the Dunghan and Gházij groups to be determined with accuracy, when this would, in its absence, have proved almost impossible of accomplishment.

Fossils.

Concurrently with the change of facies of the Dunghan group it becomes abundantly fossiliferous, and a large number of specimens were obtained from the shaly beds. When the fauna of this group comes to be examined in detail, I anticipate it will lead to results as striking in their way as the remarkable change which, within twenty miles, converts a group of marine limestones, 2,000 feet in thickness, into an almost entirely argillaceous group. Until the fossils collected have been examined by a competent palæontologist it would be presumptuous to hazard an opinion as to the palæontological affinity of the fauna as a whole, but it presents certain striking anomalies which cannot be passed over in silence.

Anomalous fauna.

Among the *Cephalopoda* collected were fragments of two species of *Ammonites*, *Crioceras*, and besides these I have been shown *Ceratites* and *Baculites*, which were found by Mr. R. A. Townsend in the Dés valley; among the echinodermata fully half the specimens found belong to the order *Echinoconidæ*, and an oyster very like *O. carinata* is not uncommon. These would ordinarily be held sufficient to stamp the fauna as cretaceous, or at any rate upper secondary, yet this fauna not only occurs above the white limestone of the belemnite beds, in which *Nummulina* occur, but is accompanied in the same group by an abundance of specimens of *Nummulina* belonging to three or four species. I am aware that the genus *Nummulina* has been found in beds of carboniferous and of secondary age, but it is uncommon and, as yet, it has always been accepted that any beds in which the genus is abundantly represented are of tertiary age.

Under these circumstances it must remain an open question whether we are to regard the Dunghan group as oldest tertiary, or newest secondary, in age. Dr. Blanford in his memoir [1] regarded the Dunghan limestone, near Harnai, as lower nummulitic, and very naturally so, for the almost only recognizable fossils it contains are foraminifera, mostly *Nummulina*, but in the Suleiman hills he took the "limestone breccia" to mark the base of the tertiary system. As may be seen from what I said above, there is a contradiction here and, as matters stand, it is impossible to say which of the two views is correct. If the top of the Dunghan group represents the lower limit of the tertiaries, we have to acknowledge an extreme abundance of the genus *Nummulina* in beds of cretaceous age; if the bottom, then the *Ammonoidea* are represented, in beds of tertiary age, by several genera and species. A third interpretation is open, and probably it will prove the true one, that the Dunghan group represents the gap between the Secondary and Tertiary period in Europe.

Distribution.

The distribution of the Dunghan group is a large one, and is best explained by a reference to the map. In the north-western portion of the area, where it consists mainly of limestone, it forms high hills and mountains; to the south-east, where it is shaly, this is much less noticeable as, in most cases, the thin shell of limestone has been broken through by denudation, and the easily removed shales exposed.

Gházij group.

The Dunghan group is conformably overlaid by the Gházij group which presents the same character as was described in my previous paper and will not require lengthy notice here. To the north of the Thal Chotiáli plain some coal seams occur in this group, and near Khattan a thin band of impure coal is found near the top of it, but throughout the rest of the large area it occupies no coal was seen. Fossils are not very abundant except near the top of the group.

Spintangi group.

The Gházij group is overlaid by the Spintangi beds, not only with most perfect conformity, but with an absolute obliteration of any definite boundary. In the neighbourhood of Khattan several thin beds of white limestone, of the Spintangi type, occur among the Gházij shales, and green shales are found interbedded with beds which appear to be the equivalents of the Spintangi group at Spintangi. It has become evident that the lithological discrimination of the two groups is impossible, and, on palæontological grounds, it will

[1] Memo., Geol. Surv., Ind., XX.

junction of the Bareli, there is a hill of Gházij shale, capped by sub-recent river gravels.

Thal Chotiáli.

In the Thal Chotiáli plain, separating the main area from the Karáhi plain, there are some low hills of gravels, which have been bent up into an anticlinal. These are evidently old deposits of the river, before its gradient was checked, and have since been disturbed. They will be again referred to when treating of the Thal Chotiáli plain.

Disturbance of gravels at Panuṇ.

The most remarkable instance of disturbance of these sub-recent river gravels is exhibited by those of the Panuṇ valley (Pano of the map). Between the Sherki hill and the western end of the Mazár Drik anticlinal there is a great thickness of gravels, through which the stream has cut its way. At their northern limit these are in direct contact with Gházij shales, and have been bent up vertical and in places as much as 30° beyond the vertical, so as to acquire an apparent dip to N. at 60° (Plate III). The dip is very local; within 300 yards to the south it has almost disappeared, and, throughout the area occupied by these gravels, no signs of disturbance were seen, except in the immediate vicinity of its northern margin.

Recent gravels and alluvium.

Gravels of recent date are abundant in all the stream valleys. They have not been considered of sufficient importance to be mapped in detail. Besides the numerous smaller deposits in the stream valleys there is a large area in the Quat Mandai valley, covered principally by gravels, but in part also by fine-grained alluvial deposits.

Landslips.

Among recent deposits must be classed landslips, which are more common than would be expected in so dry a climate. There is a very large and conspicuous landslip at Kuriák Tangi, 8 miles east of Spintangi, which extends for nearly 3 miles across the valley, having come from the hills to the south. This landslip must have blocked the drainage for a time, as the Tangi is cut through its substance, between its source of origin and termination.

Smaller landslips are common where the Gházij shales are exposed on a hillside, being induced by the manner in which these shales weather into slimy mud which will move over very small gradients. A very striking instance occurs south of Sonári, where, on the watershed between the drainage of the Chákar and Béji valleys, the whole outcrop of the Gházij shales is completely concealed by a thick layer of huge angular masses of Dunghan limestone. It is, at first sight, almost impossible to suppose that the limestone is not *in situ* here, but, on either side of the ridge, these blocks are seen to overlie the edges of nearly vertical beds of the Dunghan and Spintangi groups.

Alluvial and loess plains.

The most interesting and important of the recent deposits are, however, the numerous valley plains of fine-grained loess or alluvium. These vary in size from the numerous small "Thals" on the hillsides, too small to be distinguished on the map, to the great plain of Thal Chotiali, and the still greater plain of the Sibi "Pat."

The Thals are small hollows, perched about the hillsides and on the hill tops, some due to solution of the underlying limestone, others to small landslips, in which accumulations of dust and rain wash, from the surrounding hillsides, form a very gently sloping floor. They are mostly cultivated by the Maris, who have not yet been

able to get over the objection, born in old predatory days, to cultivating the valleys, where the crops are visible to every passer-by, and would probably have been reaped by some other person than the man who sowed them.

The larger plains, those of Mámand, Samach, and Púr, as well as some of the smaller ones, evidently owe their origin to differential movements, or warping, of the surface, by which the drainage was checked, and the accumulation of fine grained deposits rendered possible.

Mámand.

The plains of Púr and Mámand are both situated in synclinal hollows of the underlying rock; in the latter case the old escape of the drainage can be traced on the south side of the plain, and the old river gravels, deposited in former times when the streams flowed across the area now covered by the plains, extend over a low divide and slope gently northwards under the loess. The deposit which fills the hollow that was formed is fine and uniform in grain, of a pale grey colour, and very calcareous; the very few and shallow sections exposed show no signs of stratification, and there seems no reason to doubt that it is, in the main, wind blown leess, derived from the dust blown off the surrounding hills, supplemented to some extent, near the margins of the plains, by matter brought in by the streams. The history of the plain is evidently as follows: At first there were river valleys of the ordinary sort draining to the south. After these had been well excavated, the compression to which these hills have been subjected caused the stream bed south of the Mámand plain to rise at a greater rate than the stream could cut down its channel. The first result of this was to form a deposit of gravel filling up the hollow, but the rise of the barrier went on at a greater rate than the deposit and a hollow was formed which the materials brought down by the stream could not fill and from which the dust that accumulated could not be washed away; so the loess gradually formed and by degrees spread over the gravels, hiding them and obliterating all minor inequalities of the ground to form a nearly level plain, now cultivated over almost the whole of its area. The whole of this process, from the original carving out of the valleys to the formation and filling up of the basin, every stage of which must have been very slow and gradual in its progress, has taken place since the deposition of the sub-recent gravels mentioned above, and, when it is remembered that these are among the latest members of the tertiary period, if indeed they are tertiary at all, it gives a most striking indication of the incomprehensibly vast periods of time which the geological record must necessarily cover.

Samach.

The Samach plain differs from that of Mámand in being formed on the crest of an anticlinal, but its origin is none the less evidently due to differential movements of the surface. Its history has been as follows: In the first instance an anticlinal hill of Dunghan limestone was formed, whose crest was broken through by denudation, exposing the easily denuded shales of the lower part of that group and the Belemnite beds, and a tolerably deep valley was consequently formed, but the drainage of this valley had to cross the axis of the anticlinal, and, in consequence of further compression, the ground along the axis rose and checked the drainage, after which the subsequent history was much the same as that of the Mámand plain.

The fine grained deposits of Samach differ somewhat from those of Mámand in appearance. Whether they are calcareous or not I forgot to note, but their colour is

a reddish brown, and they are much more loamy in appearance and texture. The difference is doubtless due to the amount of fine grained argillaceous matter washed down into this plain, whereas at Mámand the bulk of the debris brought down by the streams was limestone gravel, which came to rest close to the edge of the hills.

In the Samach plain we can see the beginning of the end, for the barrier has been partly cut through and the stream has cut back into the plain, converting its eastern end into a maze of perpendicular-sided ridges and channels, while the rest of the plain still preserves its original smooth surface.

Thal Chotiáli.

The other plains of loess present very much the same character and history as these and do not require further notice here, but the great Thal Chotiáli plain, 45 miles in length and 12 in breadth, presents so many features of interest that it cannot be passed over without some mention.

The western half of the plain is a barren treeless expanse of pale grey loess, at first sight level throughout, but having in fact slight gradients to the west and south, where water collects after heavy rain. In the eastern end the soil is of a reddish colour and is less of a dead level, some slight rises being perceptible, especially near Gumbaz; and along the banks of the stream, which flows past Gumbaz and Chotiáli, there is a park-like strip in which tamarisk and poplar trees shade the stream and are dotted about with green sward under their shade, forming a view not unpicturesque in itself, and positively beautiful by contrast with the barrenness of the surrounding country. The Karáhi plain, too, is in spring a mass of verdure. In March last its centre was occupied by an expanse of water in which numberless waterfowl and waders were disporting themselves, and on the stretch of ground surrounding it countless herds of sheep, cattle, goats, and donkeys were grazing.

The fine grained deposits of the plain are of two distinct types. One of these is pale grey in colour, highly calcareous and very obscurely stratified. It corresponds to the loess deposits of the Quetta plain. The other is of a reddish brown colour, imperfectly but distinctly stratified, which appears to correspond to the undisturbed equivalents of those beds which, in the Quetta district, have been classed as Siwalik.

The drainage of the plain presents features of interest. On the north two considerable streams enter the valley. One of these drains the Sinjáwi valley and flows past Dúki. The ordinary flow of this stream is entirely absorbed by cultivation and the flood waters spread out over the plain, partly soaking into it, partly accumulating in the hollows, whence they gradually disappear by percolation and evaporation.

The other is the Hanambár stream, which is joined near Chotiáli by the Naréchi flowing from the east, and the combined waters flow out through the hills at Tang, or, as it is more commonly called, the Ghâti bridge, being there, and for the rest of their course to Babar Kach, known as the Béji river.

Present drainage outlet.

This, the only outlet for the drainage of the Thal Chotiáli plain, is not the original course of the drainage, and is, moreover, of very recent date. The hills on either side of it are low, and slope gently to the stream,[1] which does not flow in any deep cut gorge or steep-sided valley marking the long action of denudation. There are no traces of river gravels, and in the plain above the hills the stream flows in a narrow

[1] See Plate IV.

channel of 20 to 30 feet deep, from which two nullahs are cutting back on either side into the loess deposits along the foot of the hills. Everything marks the outlet as geologically of very recent origin. The stream bed, after entering the hills, is formed by deep, stagnant reaches, separated by small waterfalls or rapids, where the water flows over a steep slope of angular debris. The deepening of this channel must proceed slowly, for it can only take place through the power of the floods to tear angular masses of rock out of its bed, the waters having been deprived of all solid matter, too coarse to be carried in suspension, long before they cross the plain. This absence of pebbles borne along by the water has deprived the stream of much of its abrading power and the outlines of the stream bed, and of the loose fragments in it, are everywhere almost angular. Occasionally, however, they exhibit indistinctly the same sort of sculpturing as is seen on rocks exposed to the action of wind blown sand,[1] which is in this case caused by the fragments of sand carried along in suspension by the water.

Old course of the Béji.

After a course of a couple of miles, down what has all the appearance of the valley of a small tributary stream, as in fact it originally was, there is a broad open valley leading up to the west, and immediately beds of river shingle appear. Following up this side valley, it can easily be recognized as the old outlet of the river, which once gathered all the drainage of Thal Chotiáli. It is broad and open, and the Gházij shales, which are the rock *in situ*, are very little seen, owing to a cover of river gravels cut into by numerous small stream beds. The surface of this gravel deposit gradually rises to the west and ultimately forms a broad and almost imperceptible ridge at the eastern end of the Karáhi plain. The same gravels are seen in the ridge of low hills, which runs east and west, north of the Karáhi plain, where they are disturbed, forming in places the whole of the ridge, but, in others, only a skin over a central core of older rocks.

We have here the old course in which the Béji river flowed; its flow was checked by a rise of its bed along the anticlinal which runs south of the Karáhi plain, and finally closed by the rise of the ground at its eastern end. The formation of the low hills, separating this from the main area of the Thal Chotiáli plain, was of later date, and it is noteworthy that these hills lie along the continuation of a distinct anticlinal.

History of the plain.

The evidence that the compression and folding of the strata did not take place at one definite period and then cease, but that it has been a gradual process, going on concomitantly with the erosion of the river valleys, is peculiarly abundant in the Thal Chotiáli district, and it would be most interesting to work out the details with greater thoroughness than I was able to do on my somewhat hurried visit. We have first a certain amount of disturbance, the formation of a large drainage basin and extensive denudation. Then we have earth movements by which an area of closed drainage was formed and deposits accumulated; at a subsequent date a further movement caused the elevation of the low hills between Ismail Khan and the Karáhi plain, and, at a still later date, some of the fine grained loess deposits along the margin of the hills west of the Ghâti bridge have been locally elevated and deeply cut into by the resulting erosion. Meanwhile the surface of the plain had gradually risen,

[1] See Records, Vol XXI, page 159.

extending up a small tributary valley which originally flowed northwards past where the Ghâti bridge now stands, till its level reached that of the divide. Some of the flood waters then flowed over this and, washing away the weathered and easily removable rock at the surface, established a defined channel, along which much of the drainage now escapes. Such are the main points in the history of the Thal Chotiâli plain.

Economic geology.

The economic results of the last season's work have been as disappointing as its purely geological results have been interesting.

Petroleum.

Traces of petroleum are widespread, and were found in the limestones of the Dunghan group at several spots throughout the area surveyed. It is most concentrated along the Khattan anticlinal. Old flows can be found in the Dés valley, and, in a corresponding valley, which drains the south side of the anticlinal. The shows are most abundant about the horizon of the red sandstone mentioned in the description of the Dunghan group. It is worthy of note that where this group is most profusely fossiliferous, most conspicuous signs of petroleum are found, and it is impossible not to hazard a guess that the coincidence is not accidental. As this petroleum has already been noticed in a previous paper[1] and been made the subject of a special report, I shall not enter further into the matter.

Coal.

Coal was found near Duki in several places, but the thickest seam seen only measured 14 inches, so it is not likely ever to be of importance. The distance from any centre of demand would very much detract from its value even if good seams existed.

Gypsum.

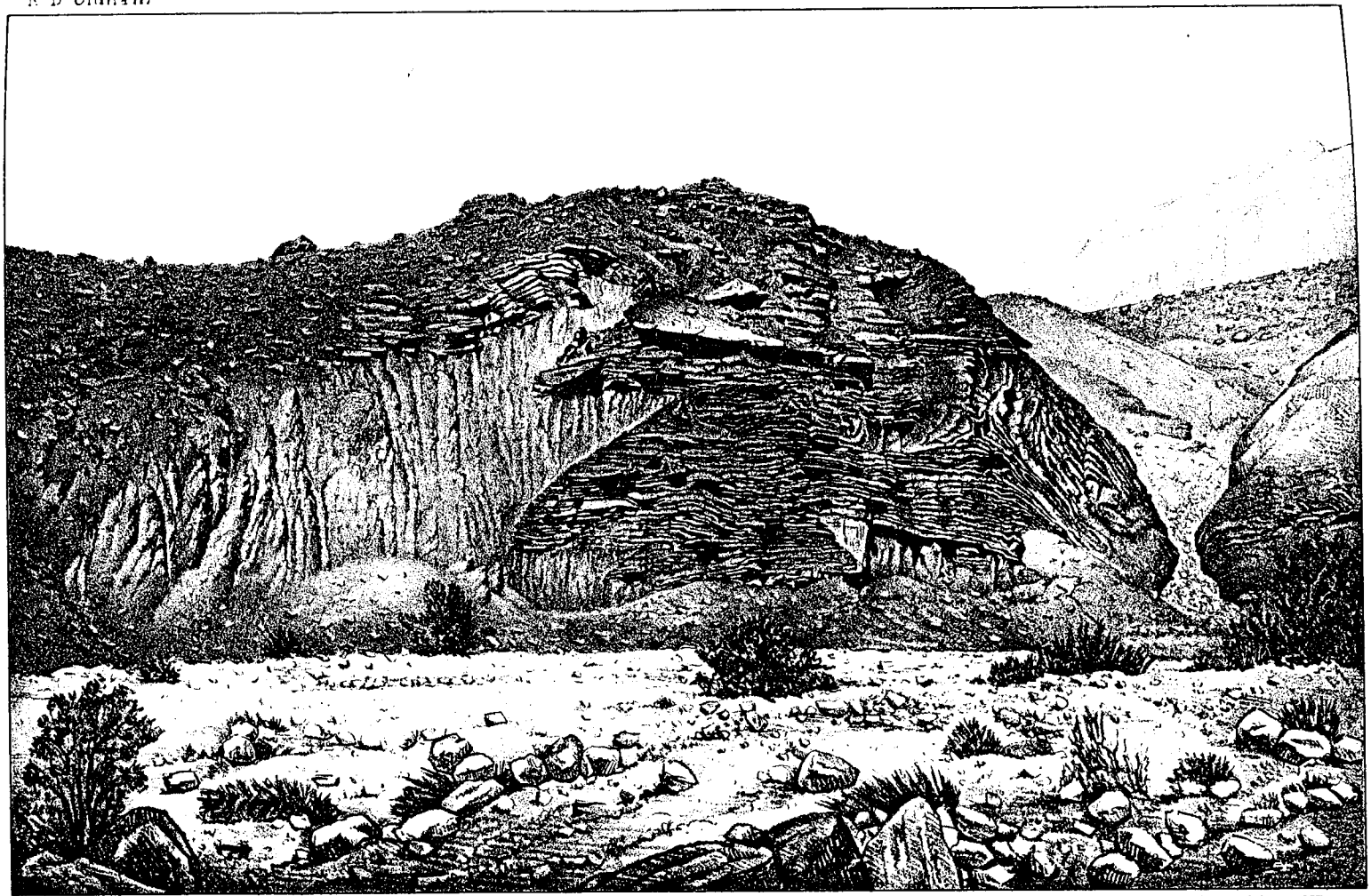
Gypsum was observed in great abundance and thick beds, one measuring 50 feet, near Mámand and in the Khattan valley; it will be long before it is worked for profit, though it is of excellent quality, and, if it could be easily got out, could be used for ornamental purposes.

Petrological Notes *on the* Boulder-bed *of the* Salt Range, Panjáb, *by* C. S. MIDDLEMISS, B.A., *Geological Survey of India.*

INTRODUCTION.

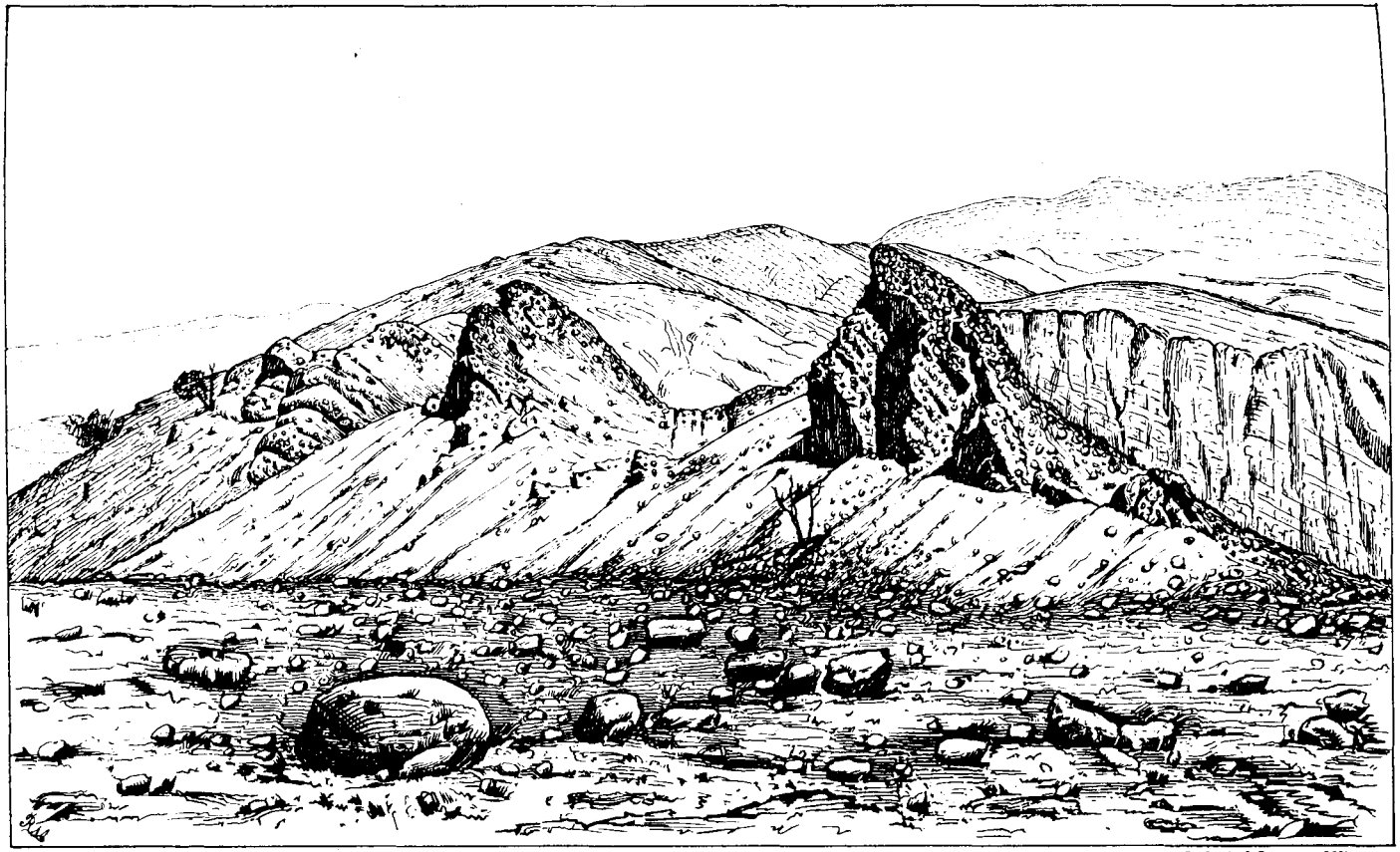
The rock-formation known as the Boulder-bed of the Salt Range is one that has attracted much attention of late, as previous papers in the Records by Warth, Oldham, Blanford, Waagen, Medlicott, and myself during the last few years can testify. It is unnecessary here to do more than shortly re-state what has now been definitely established as regards its age and mode of formation. Instead of there being several crystalline boulder-beds at different horizons in the range, it has been abundantly proved that there is but one bed forming a bottom layer to the Speckled Sandstone stage and its eastern representative, and resting unconformably on the older palæo-

[1] Rec., Geol. Surv. Ind., XXIII, page 104 (1890).



Lithographed & Printed at Geological Survey Office.

PLATE. I. REVERSED FAULTING IN GHAZIJ BEDS NEAR THE DUNGHAN MOUNTAIN



Lithographed & Printed at Geological Survey Office.

PLATE III. DISTURBED RECENT RIVER GRAVELS AT PANUN

Lithographed & Printed at Geological Survey Office.

PLATE. IV. OUTLET OF BÉJI RIVER FROM THE THAL CHOTIALI PLAIN.

Part of

THAL-CHOTIALI

AND THE

MARI COUNTRY

Surveyed in 1890-91 by

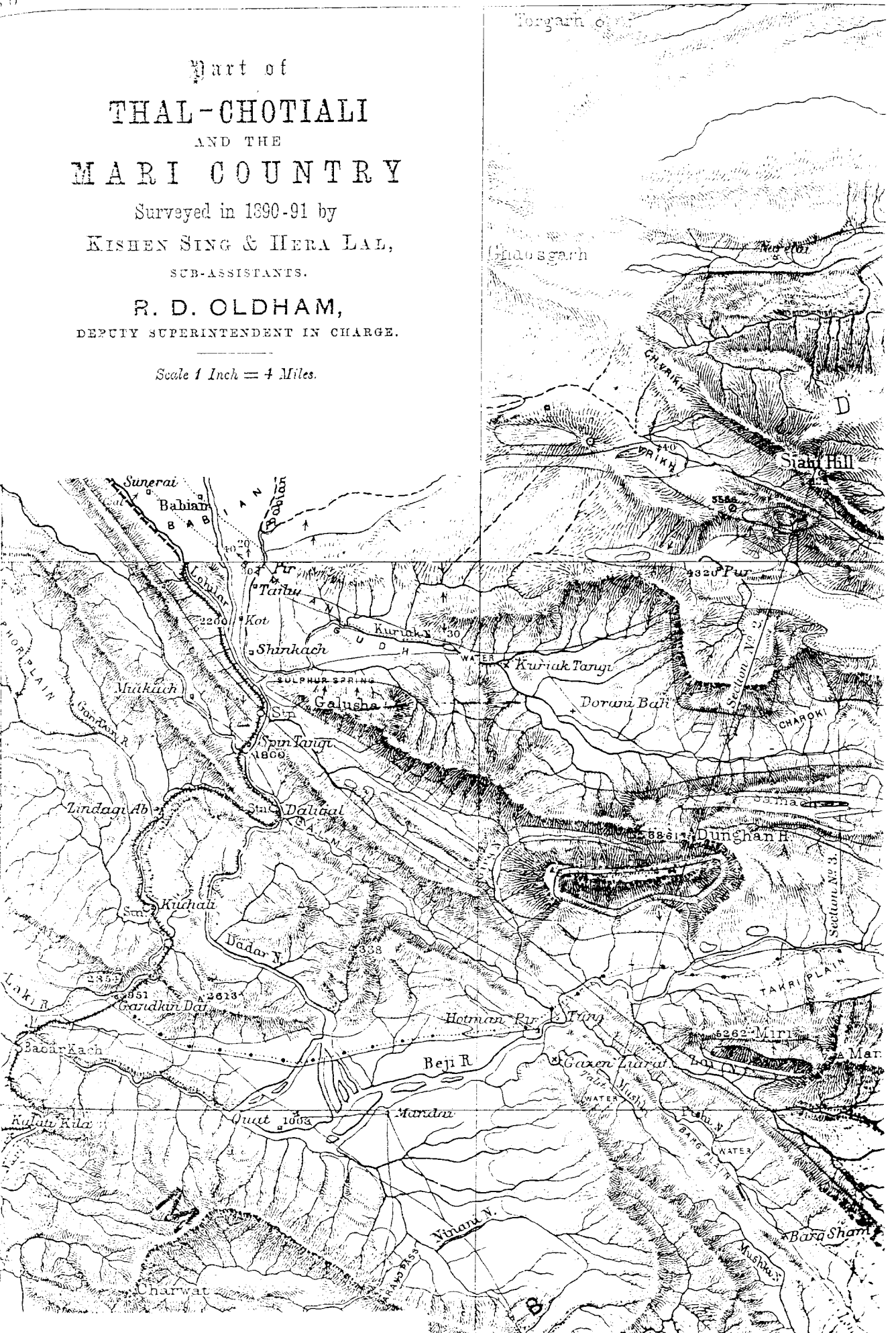
KISHEN SING & HERA LAL,

SUB-ASSISTANTS.

R. D. OLDHAM,

DEPUTY SUPERINTENDENT IN CHARGE.

Scale 1 Inch = 4 Miles.



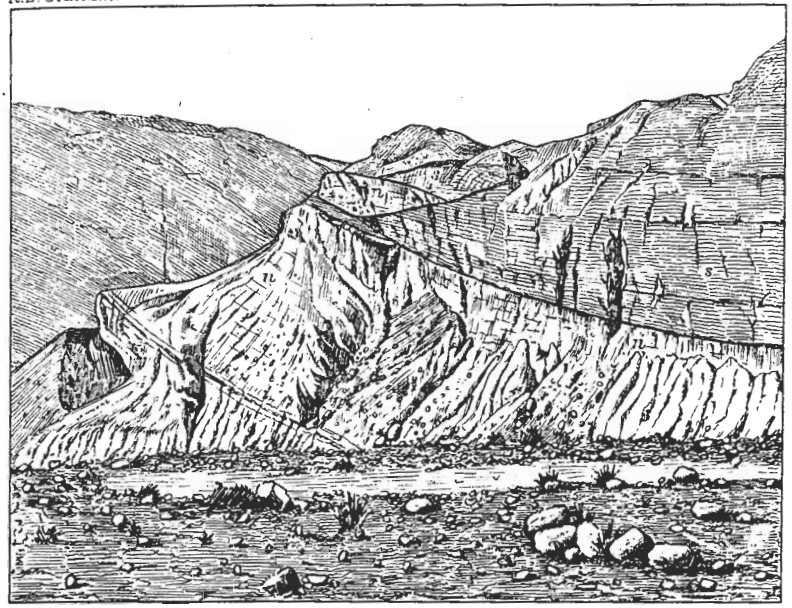


Fig. I.

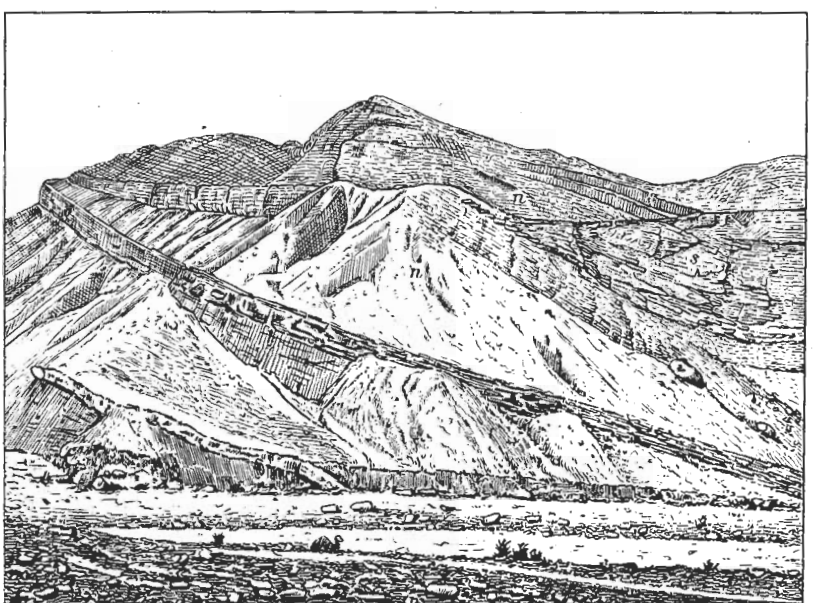
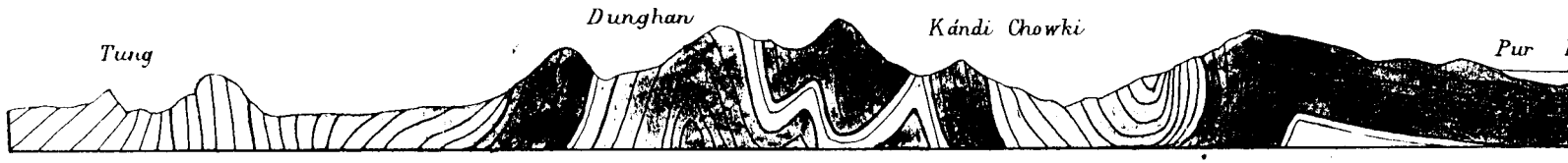


Fig. II.

Lithographed & Printed at Geological Survey Office.

PLATE. II. JUNCTION OF NUMMULITICS & SIWALIKS ON ROAD TO KHATTAN, SHOWING SMALL THRUST PLANE.

n. Nummulitic. s. Siwalik.

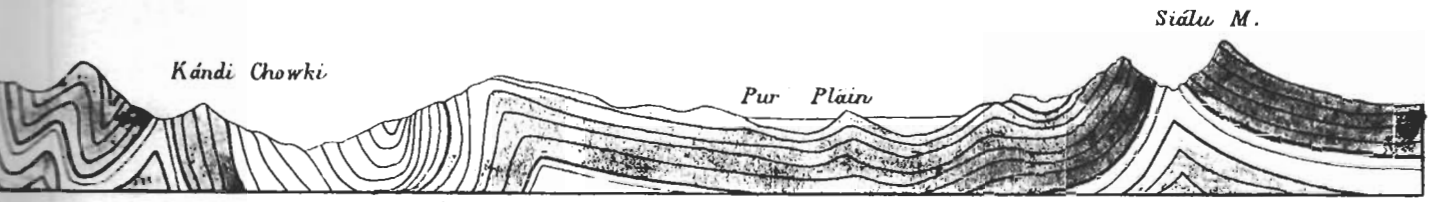


Section from Tung to the Siálu Hill.

N. and S. from Sémbar to Dés.

Sketch Section through the East end of the Samach Plain.

Lithographed & Printed at



Tung to the Siálu Hill.